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SCIENCE ABSTRACTS

SECTION A.—PHYSICS.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1924.

GENERAL PHYSICS.

2651. *The Viscosity of Rubber (dissolved) in Ordinary and in Acidified Benzene.* **O. de Vries.** (K. Akad. Amsterdam, Proc. 27. 3–4. pp. 249–264, 1924.)—Particulars are given of the change in the values of the viscosity of a 1 % solution of various samples of rubber dissolved in benzene, produced by the addition of hydrochloric acid, the resulting concentration of the acid being of the order 5–10 milli-mols. per litre. It is suggested that in the case of inferior grades of rubber valuable information concerning the quality of the rubber is afforded by a determination of the viscosity of the acidified solution in benzene. J. S. G. T.

2652. *Note on the Stability of Laminar Shearing Motion in a Viscous Incompressible Fluid.* **R. V. Southwell.** (Phil. Mag. 48. pp. 540–553, Sept., 1924. Paper read at the Internat. Congress, Delft, 1924.)—Using the results of a recent paper [Abstract 2000 (1924)] upon the instability of a flat elastic strip under shear, in which the energy equation (but not *all* the differential equations) is formally identical with that for disturbed laminar motion of a viscous fluid between two planes, and Rayleigh's method, if investigating the stability by means of an approximate solution (which always *over-estimates* the stability), Orr's result that the fluid motion cannot be unstable if the Reynolds' number is less than 177 is reproduced. It is pointed out that the question as to whether or no the motion becomes unstable for higher values of the Reynolds' number is, unfortunately, still left open. W. G. B.

2653. *Discontinuous Flow of Liquid Past a Wedge of Small Angle.* **W. B. Morton.** (Phil. Mag. 48. pp. 464–476, Sept., 1924.)—A continuation of a former paper [Abstract 1363 (1921)] giving some approximations for a wedge of small angle. Provided the direction of the free stream divides the angle of the wedge in a ratio depending upon the lengths of the sides, the stream divides at the apex, and runs along two faces of the wedge. If this is not the case, however, and the stream divides at a point on one of the faces, the stream line leaves the wedge at the apex, bends round, and may hit the other face, enclosing a pocket of dead water. Using approximations for a wedge of small angle, the

limiting length of the second face, the thrust, and the variations of velocity along the face are calculated. W. G. B.

2654. *Properties of Powders. Part VIII. Influence of Velocity of Compression on Apparent Compressibility.* **E. E. Walker.** (Faraday Soc., Trans. 19. pp. 614–620; Disc., 620–622, March, 1924.)—When a powder is compressed in a cylinder by a constant load the velocity of compression is very high at first and then rapidly falls off. The relationship between the length of time for which the load has been applied and the velocity with which compression takes place is calculated from the equation

$$\text{Velocity of compression} = -\frac{dV}{dt} = K't^{-0.9}$$

where V is volume ratio, t the load, and K′ the velocity coefficient. The author calculates the relationship between the resistance which a powder offers to compression by impact of known velocity (R_i) and its resistance to a static load of known duration (R_p) from the equation $\log_{10}\frac{R_i}{R_p}=10\frac{K'}{K}\left\{t^{1/10}-\left(\frac{K'Q}{5v}\right)^{1/9}\right\}$ where v = impact velocity of falling weight in cm./sec., Q = quantity of powder in cu. cm., and gives the results in a table. The case of powdered ammonium nitrate is fully discussed, and figures are given to demonstrate that it is quite specially liable to shrink under the influence of prolonged external pressure and when acted upon by capillary forces. In the *Discussion*, **E. P. Perman** states that as the result of experiments he found the following: (1) *No* moisture, *no* shrinkage; (2) rapid increase of shrinkage with increase of moisture; (3) the greater the solubility, the greater the shrinkage. [See Abstracts 193 and 194 (1924).] T. C. H.

2655. *The Representation in Finite Terms of Irregular or Polygonal Periodic Functions.* **L. Laboccetta.** (Elettrotecnica, 11. pp. 442–452, July 5; 471–480, July 15, and pp. 496–502, July 25, 1924.)—To express polygonal functions in finite terms use is made of certain simple discontinuous functions. The discontinuous functions defined are: $y = Ix$ where y is the integral part of any positive real number x; $\text{Fr}\,x = x - Ix$; $\text{Cm}\,x = (1 + Ix) - x$; $\text{Sgn}\,x = x/|x|$. The function expressed by $y = I^{-1}n$ and the analogous ones are defined as strips of definite position on a plane. Many polygonal periodic functions can be written down directly in terms of these functions and are at the same time more exact and less cumbrous than the large number of Fourier terms necessary to secure reasonable accuracy. For instance

$$\text{Fr}(x/2\pi) = \pi - 2(\sin x + \sin 2x/2 + \sin 3x/3 + \ldots)$$

It is also necessary to secure a means of making some portions of a polygonal function disappear. This is most simply done by multiplying by another discontinuous function which has the constant value + 1 except over the range of x, for which the function is to disappear and in these regions to be unreal. Such functions are written in general:—

$$\phi\left(\frac{i}{1}\right)$$

Two functions which are periodic and fulfil these conditions are :—

$$\tfrac{1}{2}[1 + (-1)^{I(x+1)}] + \tfrac{1}{2}i[1 - (-1)^{I(x+1)}]$$
$$\tfrac{1}{2}[(1 + \mathrm{Sgn}\sin\pi x)] + \tfrac{1}{2}i[(1 - \mathrm{Sgn}\sin\pi x)]$$

The methods of describing and building up polygonal functions are outlined and frequently illustrated, and similar methods applied to functions involving portions of continuous functions with discontinuities or polygonal regions between them. Under this head are dealt with trains of pulses and harmonic waves limited or reflected regularly. Methods for introducing continuous changes of scale, amplitude or frequency are dealt with and the processes of differentiation and integration of these functions described. A large number of examples are given throughout the paper. A. Wh.

2656. *On a Suitable Example of Motion in the General Problem of Three Bodies.* **K. Bohlin.** (Astron. Iakttagelser och Undersökningar, Stockholm, 10. 11. [32 pp.] 1923.)—A brief introduction to periodic orbits in the problem of three bodies is first given, following which comes the discussion, with numerical calculations, of the special case where masses and distances are of the same dimensional order, a problem first treated by Strömgren. The paper is entirely mathematical and accompanied by voluminous numerical data. H. H. Ho.

2657. *Singular Points of Circular Cubics.* **H. Pflieger-Haertel.** (Archiv f. Elektrot. 13. pp. 396–402, Aug. 22, 1924.)—A purely mathematical paper, in which the author develops a method of determining the nature of the singular point of the curve represented by the equation $W = (A + Bu + Cu^2)/(D + Eu)$, wherein A, B, C, D, E and W are complex numbers and u is a real parameter. A. H.

2658. *Concerning the Paradox of d'Alembert.* **U. Cisotti.** (Comptes Rendus, 178. pp. 1792–1793, May 26, 1924.)—States as a general conclusion of his researches that " for *all* fluids (compressible or not), provided the velocity does not exceed a certain limit " (the limit depending, for liquids, upon density, pressure, and field of force, and in addition, for compressible fluids, upon the velocity of sound) the theorems grouped under the general term " paradox of d'Alembert " hold. W. G. B.

2659. *Researches on Metal Crystals. (I) Elastic Constants, and (II) Specific Heat and Electrical Resistance of Zinc and Cadmium.* **E. Grüneisen** and **E. Goens.** (Zeits. f. Physik, 26. 4–5. pp. 235–249 and 250–273, 1924. From the Reichsanstalt.)—By placing a small crystal upon the surface of the molten metal, and drawing it up through a hole in a mica sheet floating thereon, a bar of metal, with the crystalline axis inclined at a constant angle to the axis of figure, and of approximately circular cross-section (20 cm. long, 0·25 cm. diam.) is obtained. The inclination of the axis may be measured by the angle of fracture, by X-rays, and by the coefficient of linear expansion. The moduli of elasticity were measured : Young's modulus by clamping centrally and determining the frequency of vibration, the shear modulus by static torsion. From the results, for a series of angles of inclination, the five elastic constants were calculated. In the second part these results are used to calculate the effect of anisotropy upon the specific heat, as

deduced from Born's theory, and also to the anisotropic electrical resistance. Good agreement with experiment is obtained. W. G. B.

2660. *Atomic Theory.* **M. Born.** (Elekt. Zeits. 45. pp. 889–897, Aug. 21, 1924. Paper read before the Verband. Deut. Elektrot., Dresden, Aug., 1924.)—This paper contains a comprehensive review in nine sections of the present position of the atomic theory. § 1 deals with the periodic system of the elements. § 2 discusses the fundamental laws of atomistic mechanics. § 3 investigates the connection between the energy change of atoms and the wave-lengths of the emitted and absorbed light, and thereby briefly considers the quantum theory. § 4 is devoted to the spectrum laws. § 5 describes the Bohr theory of the hydrogen atom. § 6 deals with the fine structure of spectral lines and with the Zeeman and Stark effects. § 7 is occupied with the spectra of the higher atoms and the true quantum numbers, leading in § 8 to a consideration of the structure of the periodic system. § 9 finally deals with the limits to the present theory. The gaps in the current state of quantum mechanics are referred to, and the necessity emphasised for a physics of discontinuity with difference equations in place of the classical differential equations. The final paragraph is devoted to the structure of the nucleus. The paper itself is an admirable *résumé* of the subject in concise and readable form. H. H. Ho.

2661. *Diameters of Atoms of the Inert Gases.* **J. E. Calthrop.** (Phil. Mag. 48. pp. 79–81, July, 1924.)—On the whole the evidence of refractivity seems to be in favour of the W. L. Bragg diameters as against the Davey diameters. A. D.

2662. *Applicability of the Quantum Theory to the Magnetic Field.* **W. Gerlach** and **O. Stern.** (Ann. d. Physik, 74. 8. pp. 673–699, Aug., 1924.)—The description of previous work in more expanded form [see Abstract 2055 (1922)]. The work forms an experimental proof of the Debye-Sommerfeld quantification in the magnetic field, and shows that the silver atom in normal condition contains one Bohr magneton. G. E. A.

2663. *Atomic Magnetic Moments.* **W. Gerlach** and **A. C. Cilliers.** (Zeits. f. Physik, 26. 2. pp. 106–109, 1924.)—The paper is a continuation of the work of Gerlach and Stern [Abstract 2055 (1922)] on the determination of the magnetic constants of single atoms under normal conditions. A stream of atoms is driven through small holes in two screens and emerges as a ray into a magnetic field several centimetres long. Finally the ray is incident on a small plate. The magnetic field used was about 12,000 Gauss. The apparatus was altered to eliminate the previous difficulties and duplicated. In the first case a magnetic field length of 3 cm. and total ray length of 9 cm. was used, and in the second case the magnetic field length was 4·5 cm. and the atomic stream path 15 cms. long. The effect of the influence of a magnetic field of force on atoms of silver, copper, gold, thallium, lead, tin, and bismuth was investigated. The results showed that under normal conditions copper and gold atoms have a magnetic moment equal to that of the Bohr magneton, thallium has a magnetic moment of its atom less than that of the Bohr magneton, lead is non-magnetic, silver is just affected, tin and bismuth gave inconclusive results and are the subject of further

work. Ag, Cu, Au, Tl, and Pb gave quite definite results which were in agreement with theoretical anticipations. S. G. B.

2664. *Atomic Structure and the Disintegration of Atoms.* **M. v. Laue.** (Zeits. Vereines deutsch. Ing. 68. pp. 769–773, July 26, 1924.)—A lecture delivered before the Berlin branch of the Verein, tracing the history of the atomic theory, with special emphasis on the relation between the results of spectral analysis and the Bohr model, including, of course, the X-ray spectrum. There are a number of very useful explanatory diagrams, and the paper gives a very clear general view of the subject. The author speaks of Balmer, who gave the first elucidation of the hydrogen spectrum, as a numerical mystic, who sought everywhere in nature for a connection with numbers; in the course of this somewhat fantastic search he made this great discovery. Calling attention to the difficulties involved in the modern theory, he concludes by saying that, whatever the future developments may be, the conquests of the Bohr theory can never be lost to science. H. N. A.

2665. *Characteristics of Electrons in Atoms.* **R. A. Millikan.** (Science, 59. pp. 473–476, May 30, 1924.)—A recapitulation of the evidence in favour of orbital rather than stationary electrons. As well as past work, stress is laid on recent work by Millikan and Bowen. By producing "hot sparks" in high vacua, the valency electrons can be successively stripped from the atoms of the lighter elements and the case of a single electron and a nucleus studied. The theory of this case has been well developed by Sommerfeld, and the results are in complete accord with the orbital theory. A discrepancy appears, however, to exist between the types of orbits existing in atoms and the orbits which have been postulated to exist in much recent theory. A. Wh.

2666. *Electrons and Atomic Structure.* **R. A. Millikan.** (Chem. Soc., J. 125. pp. 1405–1417, July, 1924. Faraday Lecture.)—The direct demonstration and measurement of the electron by the oil drop method is described and the theories of the electronic structure of atoms outlined. The correctness of the orbital theory has been further substantiated by the recent work of Bowen and the author on the spectra of atoms stripped of all but one of their electrons. Thus the case of a progressively increasing nucleus with a single rotating electron has been compared with theory. The agreement is exact. Compton's application of the conservation of momentum and the quantum theory to the scattering of ether waves by electrons is noted as evidence in favour of the localised nature of quanta of radiation. [See preceding Abstract.] A. Wh.

2667. *Atomic Structure and Radiations.* **R. A. Millikan.** (Nature, 114. pp. 141–143, July 26, 1924. Abstract of three lectures delivered at University College, London, June, 1924.)—The first lecture is concerned with recent work tending to fill up the gap between ultra-violet and Röntgen radiations. By dealing with stripped atoms, Bowen and the author have been able to deal with such a simple series of structures that it has been possible to apply Röntgen-ray relations in the field of optics. [See preceding Abstracts.] Though there still exists a gap of nearly three octaves where no radiation has been observed, it is now possible to calculate across the gap and to predict the properties of the

radiation within it. New ideas have to be introduced as to the form and arrangement of the electronic orbits. The third lecture deals with the penetrating radiation in the atmosphere. From measurements of the radiation at various altitudes, both within and without lead-shielded vessels, the conclusion is drawn that there is no evidence of any radiation of other than local origin. The absorption coefficient of the radiation indicates that it is little harder than the γ-radiation from ordinary radio-active materials. The presence of increased concentrations of radio-active material in the upper atmosphere is not explained. A. Wh.

2668. *Dimensional Analysis.* **E. Buckingham.** (Phil. Mag. 48. pp. 141–145, July, 1924.)—The paper is a criticism of N. Campbell's recent paper on the subject [Abstract 1059 (1924)], with much of which the author agrees, but considers that the final impression it leaves is false, owing to its exaggeration. The reports of the National Physical Laboratory and the records of experimental work by the staffs of the Engineering and Aerodynamics Departments show that dimensional analysis is a very valuable tool. Its employment for deducing new relations in pure physics without laborious investigation, which, it was evident beforehand, would involve unknown constants, was the one most used by the late Lord Rayleigh, and in Rayleigh's hands it proved most valuable. But this is the kind of problem in which mistakes in its use are most likely to be made by the ordinary investigator. Its main value is as a guide in planning experimental work and in analysing and explaining the observed results. It is most useful in technical physics where complex problems depending upon many variables may be pressing for solution, even if the immediately available solution be only a rough approximation. G. W. de T.

2669. *Conservation of Impulse during Stimulation- and Ionisation-Shock.* **G. Joos** and **H. Kulenkampff.** (Phys. Zeits. 25. pp. 257–263, June 1, 1924.)—Let W_0 be the initial energy of an atom, W_2 its energy after impact but before emission, and W_1 its final energy after emission; then, for a frequency ν, $h\nu = (W_2 - W_1)$ under the condition that $\frac{1}{2}mv^2 \geq (W_2 - W_0)$. It is of advantage to assume also the conservation of impulse; in the case of impact with an electron this leads only to a small correction, but in the case of canal-rays the correction is important. With small relative velocities the whole atom is affected; slow canal-rays must travel with at least twice the velocity of electrons which produce the same stimulation, and such a shock is associated with a more rapid communication of velocity to the atom affected. With greater relative velocities, single electrons in the atoms are displaced; the atom as a whole is not displaced; the limiting velocity for stimulation stands considerably higher. Between these extremes we have intermediate cases. A. D.

2670. *Central Orbits in Relativistic Dynamics treated by Hamilton-Jacobi Method.* **G. Temple.** (Phil. Mag. 48. pp. 277–292, Aug., 1924.)—This paper consists of two parts. In Part I the author gives an exposition of a process of integration applicable in particle dynamics on any relativistic theory, and forming the appropriate generalisation of the methods of Hamilton and Jacobi in classical mechanics. The author points out that in the treatment of the Bohr H atom according to the

restricted relativity theory, Sommerfeld has made use of this method, but so far it has not been employed in general relativity theory. The reduction of particle dynamics according to general relativity to a system of canonical equations is here effected without having to make any hypothesis regarding the actual form of the laws of gravity and of electro-magnetism. In Part II the author discusses the problem of planetary motion, making the usual assumptions that the sun is at rest, and that perturbations due to the attraction of planets other than the one whose motion is considered may be neglected, according to (*a*) Einstein's law; (*b*) Whitehead's first law, expressible in integral form; (*c*) Whitehead's second law, expressible by two sets other than Einstein's of differential tensor equations (see Whitehead's Principle of Relativity, pp. 86–87). Whitehead has shown that these four sets of tensor equations fulfil the general requirements—to have no arbitrary reference to any one particular time-system, to give the Newtonian term of the inverse square law, and to yield the small corrections which explain various residual results which cannot be deduced as effects of the main Newtonian law—and give results differing only by amounts which so far appear too small for discrimination by observation. It is shown in the present paper that, on the assumptions made, the formulæ (*a*) and (*b*) are exactly equivalent and that the equations of type (*c*) involve an arbitrary function which can be chosen so as to yield the same equation as (*a*) and (*b*). Thus no observations of the forms of planetary orbits can discriminate between the three types. The author calls attention to the fact that the method here developed of treating the problem of central orbits according to relatavistic theories has the two advantages of dispensing with the tedious calculation of the Christoffel 3-index symbols and focussing attention at once on a differential equation, the solution of which furnishes the key to the whole problem. A bibliography of fifteen original papers referred to is appended to the paper. G. W. de T.

2671. *Relativistic Motion of Rigid Solid.* **G. Lemaître.** (Phil. Mag. 48. pp. 164–176, July, 1924.)—The author points out that: (1) The variable motion of a solid and the correlative aspects of phenomena for moving observers is a problem intermediate to the initial relativity theory of uniform motion and Einstein's general theory; (2) the fundamental paper on this question is that in which M. Born [see Abstract 1723 (1909)] fixed the general meaning of the interval and its spacio-temporal interpretation as retained in Einstein's general theory; (3) the necessity of rejecting the Euclidean geometry in Born's conception has been pointed out by Ehrenfest; (4) G. Herglotz has investigated the most general possible movement of a solid in a Galilean field. The author summarises these results and deduces developments and applications suggested by the present point of view of Einstein relativity. G. W. de T.

2672. *The Earth as Reference System for Light Rays.* **L. Silberstein.** (Eastman Kodak Co. Research Lab., Comm. No. 212. Phil. Mag. 48. pp. 395–404, May, 1924.)—The author's aim is to emphasise the need for our earth's experimental investigation as a reference system, without bias regarding Einstein's relativity theory. As a mechanical reference frame it is anisotropic and symmetrical around an axis practically fixed in the frame, and typified, say, by the Foucault pendulum, gyrocompass, and projectile, behaving as determined by Newton's rotating axis

equations condensed, if r be the position vector of a particle, in the vector equation $(d/dt + V\tilde{\omega})^2 r = F$, or, developed, $\ddot{r} = F - 2V\tilde{\omega}\dot{r} + \omega^2 r - \tilde{\omega}(\tilde{\omega}r) \ldots$ (1), where $\tilde{\omega}$ is a constant along the axis of symmetry (SN) and ω is its absolute value. Regarded intrinsically, from a purely terrestrial point of view, the constant $\tilde{\omega}$ is simply an ascertainable physical directed magnitude pertaining to the earth as a reference frame for mechanical phenomena. Of the two supplementary terms in (1), the first normal to the earth's axis and the particle's velocity is known as the "Coriolis force," and the remaining two, amounting together to a transversal vector away from the axis of size $\omega^2\rho$ as the "centrifugal force" per unit mass. Thus far the earth as a mechanical frame.

As an optical reference frame the Michelson-Morley experiment shows that if three points, O, A, B, be marked on a stone slab—the support of the interferometer, with O A and O B roughly equal and perpendicular to each other—then, whatever the phase difference or time lag between the light signalling O A A O and O B B O in one orientation of the slab, it remains the same for any other. Consider now 1, 2, 3, three non-collinear fixed terrestrial stations. Let two light signals be sent over the courses 1 2 3 1 and 1 3 2 1. Is there any time lag $\Delta = t_{1231} - t_{1321}$? And if there be, on what circumstances does it depend and in what manner? A reliable and definite answer to these questions can be obtained only from experiment on a somewhat large scale. Preliminary experiments to that purpose are now in progress at Passadena under the direction of Michelson.

The author goes on to argue that in the case of a *material* ether there would be no definite relation between the mechanical and optical properties of any reference framework, while Einstein's relativity theory intimately ties mechanical and optical phenomena together. He also mentions that, according to Einstein's admission (in a private conversation), the correct values of the centrifugal and the Coriolis force can be obtained only by accepting his cosmological hypothesis of a closed space and uniform mass distribution throughout it. The rotation of the whole universe around us will then give the desired result. G. W. de T.

2673. *General Conditions which must be satisfied by a Theory of the Universe conforming with the General Theory of Relativity.* **Lémeray.** (Comptes Rendus, 179. pp. 98–100, July 16, 1924.)—The author discusses very briefly the significance of matter and radiation, physical straight lines, geodesics, inertia, density and Newtonian attraction in a universe conforming to the general theory of relativity. The author suggests that stellar movements probably arise owing to lack of uniformity in the stellar distribution. J. S. G. T.

2674. *Mass as a Function of Gravitational Potential.* **A. H. Bucherer.** (Zeits. f. Physik, 26. 3. pp. 188–195, 1924.)—A previous paper by the same author [Abstract 821 (1923)] determined the mass of a light quantum in a gravitational field and then, by deduction, the formula so found was assigned to ordinary matter. The relation given was

$$M = M_0\left(1 + \frac{\mu}{rc_0^2}\right)$$

where M_0 = the mass and c_0 = the velocity of light outside the range of the gravitational force of which the potential is $-\mu/r$. The object of

the present work is to establish this formula directly without reference to the light quantum theory. The author accomplishes this by means of considerations of energy and the theory of atomic structure. The mass of a body existing in a gravitational field is deduced as a function of the gravitational potential, and the result is then applied to light radiation. From a knowledge of the kinetic energy of a moving body in a gravitational field the radial energy and the transverse energy along two directions are established in accordance with the law of the parallelogram of velocities, and along with it are considered the other established formulæ for the variation of mass. It is shown that the experimentally determined dependence of mass on velocity can be established from planetary motion, apart from the Einstein theory. The expressions finally established are strictly orthodox, and are applied to determine certain factors regarding the motion of planets. The results of such calculations are given. S. G. B.

2675. *Superficial Distribution of Matter in the Einstein Theory of Gravitation.* **K. Lanczos.** (Ann. d. Physik, 74. 6. pp. 518–540, July, 1924.)—In a recent paper [see Abstract 1405 (1924)] Sen has dealt with a problem arising in an earlier publication by the author under the above title [see Abstract 1052 (1923)], *viz.* the boundary conditions of the gravitational field at discontinuous surfaces. Sen apparently has misunderstood the author's procedure (which the latter ascribes to its brevity), and states that the Lanczos equations all refer to a definite system of coordinates, which, according to him, should have a physical significance. The evaluation of the various transformations is also stated to involve analytical difficulties, and Sen claims his work to give no preference to any system of coordinates, the results therefrom being absolutely general. Sen considers the Lanczos idea of a metrical proof in a coordinate system which is not normal to be superfluous. The author claims in reply that his tenser equations are valid for every coordinate system, while they contain the results of a mathematical development which has only been worked out by Sen for its preliminary stages. In order to clear up possible errors, but mainly because the possibility of a superficial distribution of matter can be of specific significance from the standpoint of a general theory of matter, the method by which the earlier published results were obtained is now given at greater length. The paper is mathematical throughout, and solves the problem of the general boundary conditions of the gravitational field at discontinuous surfaces. H. H. Ho.

2676. *Determination of the Curvature Invariant of Space-Time.* **H. Weyl.** (Phil. Mag. 48. pp. 348–349, Aug., 1924.)—This is a reply to criticisms in a recent paper by L. Silberstein (see Abstract 2203 (1924)] criticising the author's work in an earlier paper [see Abstract 1774 (1923)] and in Raum-Zeit-Materie, 5th ed., 1923. The author points out that Silberstein's allegation, that "tan" should be "sin" in the author's formula for the displacement towards the red is incorrect. He also defends his expressed views on de Sitter's World against Silberstein's disparagement of them. G. W. de T.

2677. *Quantum Mechanics.* **M. Born.** (Zeits. f. Physik, 26. 6. pp. 379–395, 1924.)—The work contains an investigation which seeks to

establish the first step in quantum mechanics, as to which of the main characteristics of the atom (stability, resonance, fulfilment of the correspondence principle, etc.) furnishes adequate basis for calculation and originates from the classical laws in a natural manner. The theory includes the dispersion formula of Kramer and shows a close relationship to Heisenberg's formulæ for the rules concerning the anomalous Zeeman effect. The paper contains a mathematical discussion of the classical theory for the disturbance of a system exposed to external forces, the classical dispersion theory, and a review of the quantum theory in relation to the same problems. S. G. B.

2678. *Gravitational Anisotropy in Crystals.* **P. R. Heyl.** (Bureau of Standards, Sci. Papers No. 482. pp. 307–324, 1924.)—The present paper sets out the results of experiments in which various crystals were weighed in different axial orientations in the earth's gravitational field. Six crystals were used in all, representing the five nonisotropic crystalline systems. The reason for doing so was to see whether any gravitational anisotropy could be detected, a result which, if found, would contradict Einstein's fundamental postulate in his theory of gravitation, *viz.* that in effect gravitation and inertia are identical in their nature and indistinguishable. It is here assumed that the inertia of such crystals as were used is independent of axial direction. It was found that, to an accuracy of 1 part in 10^9, the weights of the crystals were independent of orientation, so supporting Einstein to this extent. A gravity balance by Ruprecht of Vienna was used, and the high accuracy of 1 in 10^9 was obtained by substituting for the ordinary method of arrest, by raising the beam, a clamping device due to Poynting [Roy. Soc., Proc. 28. pp. 2–35, 1878], but apparently little used. M. A. G.

2679. *Hertzian Waves and the Atmosphere.* **J. Guinchant.** (Comptes Rendus, 179. pp. 327–330, Aug. 4, 1924.)—Mirage effects are more readily attained with the long waves than with the short light-waves. The normal fall-off in the index of refraction with increasing heights ought to bring Hertzian waves *down*. The long waves, directed tangentially, travel along the surface of a conducting earth; the explanation of mirage effects is then the same as that for optical mirage from horizontal layers parallel to a plane surface. Normal meteorological variations in the atmosphere then explain momentary changes in the intensity and direction of the transmission, the difference between day and night reception, the influence of the seasons, etc. A. D.

2680. *The Significance of Regression Equations in the Analysis of Upper-Air Observations.* **F. J. W. Whipple.** (Roy. Meteorolog. Soc., J. 50. pp. 237–241; Disc., 241–243, July, 1924.)—The application of regression equations is discussed, and particular attention directed to those relating to upper-air data. It appears that no information is obtained from the regression equations beyond that furnished by the primary correlation coefficients, and that the regression equation cannot show which of two contemporary phenomena is cause and which effect. A. W. L.

2681. *The Transparency of the Atmosphere.* **J. Cabannes.** (Comptes Rendus, 179. pp. 191–193, July 21, 1924.)—Coefficients of atmospheric

transparency for various wave-lengths at Mt. Wilson (surface pressure = 623·5 mm.) have been calculated by the author ; for this computation it is assumed that the absorption in the atmosphere is due solely to the scattering of light by molecules of oxygen, nitrogen and argon. The results are in good agreement with those obtained by Fowle, but are all slightly higher. The difference is greatest for wave-lengths around 6000 Å., which coincides with the maximum absorption of ozone ; the observed difference could be explained by the presence of a layer of ozone of thickness 0·45 cm. under normal pressure. A. W. L.

2682. *The Diurnal Variation of Atmospheric Pressure at Eskdalemuir and Castle O'er, Dumfries-shire.* **C. Chree.** (Roy. Meteorolog. Soc., J. 50. pp. 245–247, July, 1924.)—In reply to a paper by A. C. Mitchell [Abstract 2018 (1924)] the author points out that (1) When dealing with the diurnal variation of pressure the comparison of the barograph with a standard mercurial barometer is not absolutely necessary, provided the scale value is correct and the compensation for variations of temperature accurate ; (2) although the mean values from all years show the minimum pressure in the morning at Castle O'er and in the afternoon at Eskdalemuir, the Eskdalemuir records for some individual years show the minimum in the morning. Fourier coefficients are given for each station and for an ideal station, the latter being found by taking the arithmetic mean of the inequalities from 1871 to 1882 for seven British observatories.

A. W. L.

2683. *The Semidiurnal Oscillation of the Atmosphere.* **S. Chapman.** (Roy. Meteorolog. Soc., J. 50. pp. 165–193 ; Disc., 193–195, July, 1924.) —The semidiurnal barometric variation is investigated dynamically, and it is concluded that the period of this oscillation is approximately the same as one of the free oscillations of the atmosphere ; consequently the variation is magnified by resonance, probably about a hundredfold. The difference between the free and forced periods is about four minutes. The relative values of the thermal and tidal influences of the sun in producing this oscillation are obtained, assuming that the thermal oscillations are produced by temperature variations conducted upwards from the ground ; the thermal part of the oscillation is found to be 0·7 of the tidal part. This ratio may require modification when accurate average values of the temperature variations in the upper air and the eddy conductivity are available for the whole earth. The phase of the oscillation might be accounted for by combining a thermal component, 135° in advance of the sun, with an equal tidal component in phase with the sun. The discrepancy between the variation of the oscillation with latitude and that obtained theoretically by Margules may be due to the variation of the mean air temperature with latitude. A. W. L.

2684. *Ascensional Rate of Pilot Balloons.* **W. C. Haines.** (Monthly Weather Rev. 52. pp. 249–253, May, 1924. Paper read before the Am. Meteorolog. Soc., Washington, 1924.)—From a study of over 800 double theodolite observations of balloons with a rate of ascent of 180 m./min., the variations in the ascensional rate at different levels have been obtained. Between the level where convection ceases (around 2000 m.) and about 5000 m. rates of ascent slightly above 180 m./min. are obtained from both morning and afternoon observations. The difference increases at higher

levels and causes an error of about 5 % in the altitude at 15,000 m. At 2000 m. about 75 % of the individual observations, and practically all morning observations taken before convection is set up, are within 10 % of the assumed rate; the departure from the assumed rate is less at higher levels. It is concluded that the ascents continued at the ordinary rate, either until the balloons burst or were lost to view; no cases have been found where the balloons reached a state of equilibrium with their surroundings and floated. A. W. L.

2685. *Is the Accuracy of Precipitation Measurements dependent upon the Area of the Receiver of the Gauge?* **F. Lindholm.** (Monthly Weather Rev. 52. pp. 262–264, May, 1924. From the German.)—An account of a comparison at several stations in Sweden of rainfall and snowfall as registered in gauges of 1000 cm.^{2} and 200 cm.^{2} receiver area. The object was to test the suitability of the smaller gauge for use in Sweden, and the conclusions drawn are (1) that the accuracy of measurement of the amount of precipitation with the smaller gauge is equal to, or perhaps a little greater than, that of the larger old Swedish gauge; (2) that the smaller gauge is well adapted to snow measurement. M. A. G.

2686. *The Rotation of Melting Ice suspended in Benzene.* **H. B. Hachey.** (Frank. Inst., J. 197. pp. 825–827, June, 1924.)—Referring to a paper by Artom [Abstract 836 (1923)], in which it is stated that a piece of ice suspended in benzol begins to rotate and continues the motion as long as the suspending thread permits, the author has repeated this experiment, using as the suspending fibre silk out of which all twist was removed by attaching a weight and leaving it in suspension over night. The conclusion reached is that ice, when suspended in benzol, does rotate, and that the speed of rotation decreases as the temperature of the benzol is lowered, and all rotation ceases when the benzol is at the temperature of 0° C. When gasoline is used instead of benzol rotation also takes place, but not when water is used. The author considers that the rotation is probably due to the downward flow of the denser water from the melting ice producing a torque, owing to its irregular motion reacting on the ice, particularly when the surrounding medium is much less dense. J. J. S.

2687. *Cloud Forms.* **Weather Bureau Cloud Committee.** (U.S. Dept. of Agriculture, Weather Bureau [22 pp.], 1924.)—Photographs of cloud forms, together with height-frequency diagrams and definitions taken from the International Cloud Atlas, are given. A. W. L.

2688. *Periodicities, Solar and Meteorological.* **C. Chree.** (Roy. Meteorolog. Soc., J. 50. pp. 87–97, April, 1924.)—An address, delivered before the Royal Meteorological Society, in the first part of which sunspot frequencies for the years 1856 to 1921 from Wolfer's lists are compared by various methods with mean yearly values of data relating to Kew Observatory, comprising rainfall, mean temperature, daily range of temperature, sunshine, cloud, mean potential gradient, absolute daily range of magnetic declination, and diurnal inequality range of declination and horizontal force for such periods as they are available. The points which the writer wishes to bring home to meteorologists are the two facts: (1) That an important sunspot relation does exist in at least one terrestrial element—terrestrial magnetism; (2) that, at least in these

latitudes, the evidence for a connection between sunspot frequency and meteorological phenomena is of quite a different order from the evidence for a connection between sunspot frequency and terrestrial magnetism.

The considerations put forward amply illustrate the danger of drawing conclusions in such matters as the present from data extending over an insufficient period of time. In the latter part of the paper the author is able, however, to suggest for trial a method by which relationships between sunspot frequencies and terrestrial elements might be investigated, even though data for the latter may not be available for a number of eleven-year periods. Reasons are given for supposing that the difference between magnetically quiet and disturbed days is essentially of the same nature as the difference between quiet days at sunspot minimum and quiet days at sunspot maximum. Granting this, any meteorological or electrical element which exhibits the eleven-year period will, it is reasonable to suppose, behave differently on days that are magnetically quiet and on days that are magnetically disturbed. The suggestion is, then, that the meteorological data relating to the two classes of days, as well as the electrical data, should be compared at a number of places, it being noted in this connection that the international lists issued from De Bilt will in future specify five disturbed days a month as well as five quiet days. It is shown to be desirable to commence with places in high magnetic latitudes as being most likely to yield best results. M. A. G.

2689. *Snowfall Measurement.* **A. Röstad.** (Geofysiske Publ. 3. 2. [15 pp.], 1924.)—Use was made of the lines of hoar-frost to find the stream-lines of wind in the neighbourhood of the snow-gauge. The vertical component of the streaming may rise to a considerable amount, introducing large errors in the determination of snowfall, but the effect is quite unimportant in the case of rain. Diagrams are given showing the disposition of the stream-lines in different cases, including the use of screens with the apparatus. For snow readings the protected gauge should be placed on horizontal ground, or, where this is not possible, the screens should be placed parallel to the ground. W. A. R.

2690. *Observations and Investigations made at the Blue Hill Meteorological Observatory.* **A. McAdie.** (Annals of the Astron. Obs. of Harvard Coll. 86. 4. pp. 203–232, 1924.)

2691. *Glaisher Stand versus Stevenson Screen; a Comparison of Forty Years' Observations of Maximum and Minimum Temperature as recorded in Both Screens at Camden Square, London.* **I. D. Margary.** (Roy. Meteorolog. Soc., J. 50. pp. 209–223; Disc., 223–226, July, 1924.)—The records considered cover the period from 1881 to 1920. If D represents the excess temperature in the Stevenson screen over that in the Glaisher, it is shown that: (1) A well-defined seasonal variation occurs in D (max.), shown both by the daily maxima and by the monthly means; the variation is from $-1{\cdot}3°$ in summer to $+0{\cdot}5°$ in winter. It is suggested that the mean monthly values of D (max.) might be used to render readings in the two screens intercomparable. (2) The values of D (min.) are generally positive, and show no definite seasonal variation; the average values obtained are $+0{\cdot}8°$ for the period 1881–1905, and $+1{\cdot}3°$ for 1905–1920, the sudden change being attributed to a rearrangement of the instruments in the Stevenson screen.

Abnormally high values, both of D (max.) and D (min.) are generally associated with northerly winds.

A further comparison between the two screens is being carried out at Kew Observatory. A. W. L.

2692. *North Sea Tides.* **J. Proudman** and **A. T. Doodson.** (Roy. Soc., Phil. Trans. 224. pp. 185–219, May 30, 1924.)—This paper deals with the principal lunar semi-diurnal constituent of the tides (M_2). It is shown that the fundamental dynamical equations of the tides may be used to obtain the distribution of the surface elevations from the observational data available. The elevations, once known, enable the directions of co-tidal and co-range lines and also the distance apart of neighbouring members of these lines to be calculated. Further from the elevation gradients and the elevation of known points the elevation can be calculated all along the line. The calculations are applied to the North Sea and its more important channels. The data and the results are given on a series of charts. W. A. R.

2693. *The Thermal State of the Earth.* **A. P. Socolow.** (J. de Physique et le Radium, 5. pp. 153–160, May, 1924.)—This paper is an attempt to derive the known thermal state of the earth from heat generated by radio-active content. The original condition of the earth is assumed to be quite cold—in fact, at absolute zero. The result of this analysis seems to show that the heat as at present manifested is not to be accounted for by the effects of radio-active processes alone. Some other source must be sought, but this need be neither the primitive heat of the Laplace hypothesis nor the heat of collision on the tidal hypothesis. The initial heat, once provided by radio-active disintegration, would be sufficient to initiate exothermic reactions among the varied chemical constituents of the crust. W. A. R.

2694. *Agincourt and Meanook Magnetic Results*, 1922–1923. **W. E. W. Jackson.** (Roy. Astron. Soc. Canada, J. 18. pp. 265–270, June-July, 1924.)

2695. *Magnetic Disturbance*, 1924. **A. L. Cortie.** (Roy. Astron. Soc., M.N. 84. pp. 531 532, May, 1924.)—The magnetic disturbance of Jan. 29 30, 1924, was not of exceptional magnitude, but noteworthy for its occurrence during a period of great solar quietude. Further investigation shows that there was a disturbed area on the sun's surface, but there was no parity in intensity nor correspondence in time between the phases of solar and terrestrial magnetic disturbance. W. A. R.

2696. *Magnetic Observations during Solar Eclipse*, 1923. **D. L. Hazard.** (Terrest. Magn. 29. pp. 57–71, June, 1924.)—Magnetic observations during solar eclipse (Sept., 1923) were especially made at Lompoc, California and also at the five stations of the U.S. Coast and Geodetic Survey. The magnetic elements are all given in a series of tables [Abstract, 1992 (1923)]. W. A. R.

2697. *Applications of Modern Physics to Astronomy.* **H. N. Russell.** (Roy. Astron. Soc. Canada, J. 18. pp. 137–164, April; 201–223, May, and pp. 233–263, June-July, 1924.) This is a condensed report, written

by H. F. Balmer, of a course of lectures delivered at the University of Toronto, February, 1924. The distribution and distances of the stars are first dealt with, the chief methods of determining stellar parallaxes being briefly described. It is then shown how the diameters of stars have been calculated, from their colour-index and apparent brightness, by applying Planck's law of radiation, and how these calculations have been confirmed by interferometer measurements of four giant stars. When the apparatus now under construction at Mt. Wilson is completed, and many more stellar diameters have been observed, if the measurements agree equally well with calculation it will be possible to conclude that the theory of black-body radiation holds for all stars, and the diameters of all can be determined. Methods of determining mass, pressure, temperature, absolute brightness, and density are also discussed.

It is next shown how modern theories of ionisation and the structure of the atom enable us to interpret stellar spectra, and an explanation of the constitution of the sun and the nature of sunspots is attempted. The sequence of stellar spectral types and the progress of evolution from giant to dwarf is described, and the age of the sun and the source of its energy is discussed. Some special problems and their possible solutions are then stated, *viz.* the clouds of calcium vapour which apparently exist between us and the hotter stars, Cepheid variables and the pulsation theory, white dwarfs, long-period variables, and novæ.

Evidence is brought forward to show that the galactic nebulæ of gaseous types, both diffuse and planetary, have lines in their spectra which are due to a known substance in an unknown state, and are shining through some form of excitation by neighbouring early B- and O-type stars, while those which have stellar spectra shine by reflection from stars of later and cooler types, and the dark nebulæ are not near enough to any star to shine. The non-galactic nebulæ, which are chiefly globular or spiral, have stellar spectra, but are believed to be luminous masses of gas shining by their own light; their forms and internal motions indicate that one type develops from another; and the calculated dimensions of a considerable number shows that they are much smaller than the Milky Way, and of about the size of globular star-clusters.

Finally, it is suggested that the earliest stage of matter known to us is that of the dark nebulæ, vast but exceedingly tenuous clouds of fine particles in turbid motion, which under the influence of gravity become gaseous, and gradually evolve into single or double stars, or, if very large, become globular and then spiral nebulæ. A brief description of the planetesmal theory, which accounts for the development of planets and satellites by tides on a slowly rotating sun, raised by a passing star, and of the special case of the earth-moon system, due to fission, concludes this sketch of the evolution of the universe. M. A. E.

2698. *Durchmusterung of Selected Areas for South Declinations, 15°, 30°, and from 45° to 90°.* **H. Shapley.** (Astron. Obs. of Harvard Coll. Annals, 102. pp. 1–276, 1923, and 103. pp. 1–344, 1924).—These volumes are the second and third parts of the Durchmusterung, whose first part forms Harvard Annals 101. The plan of measurement and reduction was devised by the late Kapteyn, and has been followed in these volumes by van Rhijn, who writes the introductions to them. The reduction of the estimated diameters of the stellar images to photographic

magnitudes in the international system rests on photographic magnitude standards, determined at Harvard College Observatory, based on the polar sequence of Harvard Annals 71, No. 3, and the magnitudes are therefore not so well determined as those in the first part, since these standards do not contain stars fainter than 13·8, and extrapolation curves must, in consequence, be used for over two magnitudes. The probable error of the magnitudes is $0^m \cdot 12$. The number of stars in Harvard Annals 102 is 65,763, and in Harvard Annals 103 is 82,226.

A. S. D. M.

2699. *Method of Extrapolation of Perturbations.* **B. V. Noumerov.** (Roy. Astron. Soc., M.N. 84. pp. 592–601, June, 1924.)—If $\bar{x}, \bar{y}, \bar{z}$ denote the special coordinates, the fundamental formula of extrapolation (for $\bar{x}$) in the case of perturbed motion is $\bar{x}_3 = \bar{x}_2(2 - \sigma) - \bar{x}_1 + R_2 + \frac{1}{12}\Delta^2 R_2 + f$, where $\bar{x} = x(1 + k^2\omega^2/12r^3)$; $\sigma(1 - \sigma/12)^2 = k^2\omega^2/r^3$; k is the Gaussian constant ; ω the interval of integration ; r the radius vector ; R the effect of a perturbing planet ; $\Delta^2 R_2$ is the second difference of R at the second moment ; and f is the correction for higher derivatives or differences beginning with the 6th order. If the interval of integration is rightly chosen, it is permissible to neglect the effect of these higher-order terms. In the Publications of the Central Astrophysical Observatory of Russia, vol. ii, Moscow, 1923, the author has given subsidiary tables for finding the interval of integration and for determining σ, and has described three methods for augmenting the interval of integration ; in the present paper he develops the method of extrapolating the perturbations of the special coordinates, which is in the main similar to that of Encke. He illustrates the method by an example of the motion of the planet Erato (62) taken from the work of Oppolzer, and finds that the divergence at the end of 25 steps of extrapolation does not exceed 10 units of the 7th decimal, which are due to cumulative errors during the process of numerical integration. This method can be applied generally to finding the differences between two perturbed motions ; for instance, the perturbations caused by Saturn can be taken into account separately, or the systematic effect of higher-order terms may be neglected in the extrapolation of perturbed coordinates.

A. S. D. M.

2700. *Maxima of Absorption Lines in Stellar Spectra. Second Paper.* **R. H. Fowler** and **E. A. Milne.** (Roy. Astron. Soc., M.N. 84. pp. 499–515, May, 1924.)—The work summarised in a previous paper [Abstract 1810 (1923)], applying the theory of high-temperature ionisation to positions of maximum intensity of absorption lines in stellar sequence of spectra, has been continued, using A. Fowler's recent discoveries of the series relationship of lines belonging to trebly-ionised silicon and to ionised carbon, and also some provisional estimates for other spectra, which are rapidly becoming available. The previous conclusion that the method indicates a temperature scale agreeing with observed temperatures for later-type stars, but giving much higher temperatures than were expected for early-type stars, is confirmed by these results for silicon and carbon. The main results of the new investigation are as follows : (1) The temperature scale for early-type stars is roughly B2 16,500° ; B1 19,000° ; Bo–O9 26,500° ; O5 more than 35,000°. (2) The partial electron pressure P_e at maximum is the mean electron pressure at which a line originates. It is fixed by fixing $T_{max.}$ for that line. For other lines and conditions P_e

increases with increasing values of gravity and increasing excitational potential, and decreases with increasing abundance of the element relative to free electrons and with increasing atomic absorption coefficient. (3) The calculated temperature difference between giants and dwarfs of the same spectral type agrees with observation. (4) The excitation potential $\chi - \chi^{(r)}$ is exceptionally large compared with χ for both He and He^+. The fractional concentration at maximum of atoms absorbing these lines is exceptionally small. (5) The concentration at maximum of normal ionized atoms capable of absorbing principal lines is exceptionally large.

M. A. E.

2701. *Distribution Function for Stellar Velocity.* **F. H. Seares.** (Mt. Wilson Observat. Contrib. No. 272. Astrophys. J. 59. pp. 274–304, June, 1924.)—Schwarzschild assumed the logarithms of the linear tangential velocities (uncorrected for solar motion) of stars of all luminosities as distributed according to a Gaussian error-curve. Since the average stellar velocity is a function of absolute magnitude, the author modifies Schwarzschild's assumption to the form $P(\log T_0)d(\log T_0) = h/\sqrt{\pi} \times e^{-h^2(\log T_0 - B)^2} \times d(\log T_0)$, where $B = \overline{\log T_0} = \log \underline{T_0} = F(M)$, which states that the values of $\log T_0$ (T_0 is linear tangential velocity uncorrected for solar motion, T is corrected) for stars of absolute magnitude M have a Gaussian distribution about the mean value $\log \underline{T_0}$. The corresponding frequency function for radial velocity freed from solar motion is $R(\theta)d\theta \propto d\theta \int_{-\infty}^{h x_1} e^{-t^2} dt$, where $x_1 = \log(\theta/2\bar{\theta}) + 3/4h_v^2 Mod$, $\bar{\theta}$ being the mean radial velocity. The investigation is based on the Gaussian distribution of the logarithms of the corrected space-velocities of 1241 stars of types F to M, and is to obtain the numerical values of the parameters h and $\log T_0$, which are: tangential velocity, corrected, $h_T = 2{\cdot}35$; uncorrected, $h = 2{\cdot}18$; corrected space-velocity, $h_v = 2{\cdot}62$; $\log T_0 = 1{\cdot}27 + 0{\cdot}052M - 0{\cdot}0019M^2$, where T_0 is expressed in km./sec. and M is referred to the international zero-point. The constant term depends on the proper motions and spectroscopic parallaxes of 875 stars nearly all brighter than M = 3, and influenced very little by selection. The coefficients of the terms in M depend on radial velocities, and if the velocities are required in astronomical units per year the constant term must be replaced by 0·59. For velocities more than 10 km./sec. the logarithms of tangential velocity, both corrected and uncorrected for solar motion, have sensibly a Gaussian distribution; for less than 10 km./sec. the Gaussian frequency function does not apply; for radial velocities freed from solar motion the deviations from a Gaussian curve are not large, but are not negligible. The relations of the tangential, radial and space-velocities follow from the single assumption of the random distribution of the correct space-velocities, and are independent of the form of the frequency functions of the various velocities. This investigation was necessary for that of the form of the luminosity function (see following abstract). In this paper (and presumably also in the following paper based on it) logarithms are to the base 10 except when explicitly stated otherwise.

A. S. D. M.

2702. *Form of Luminosity Function.* **F. H. Seares.** (Mt. Wilson Observat. Contrib. No. 273. Astrophys. J. 59. pp. 310–338, June, 1924.)—The luminosity function expresses the relative number of stars of different

absolute magnitude (M) in any limited region of space. The difficulty involved is that there are few intrinsically faint stars known, and therefore data for the two characteristics m (apparent magnitude) and μ (motion) are meagre. The author adopts Kapteyn and van Rhijn's mean parallax formula in the form of a linear function of H ($= m + 5 \log \mu$), and obtains the equation for the mean parallax $\log \bar{\pi} - \log \mu = -0{\cdot}690 - 0{\cdot}0710\mathrm{H} - 0{\cdot}0003\, m$ [hereafter referred to as m.p.] The analytical derivation of m.p. involves three fundamental distribution functions: (1) Luminosity, (2) Density (both investigated in Contrib. No. 229) [see Abstract 1561 (1922)], and (3) Linear Tangential Velocity (in No. 272 [see preceding abstract]), and from these it is shown that the equation for m.p. appears to differ for near and for distant stars. For stars near the sun (within 60 to 80 parsecs), where the density is fairly constant, the m.p. formula reduces to $\log \bar{\pi}_0 - \log \mu = -0{\cdot}71 - 0{\cdot}071\mathrm{H}$, the coefficient of m being negligible; for distant stars to $\log \bar{\pi} - \log \mu = -0{\cdot}89 - 0{\cdot}088\mathrm{H} + 0{\cdot}030m$, agreeing closely with tables of mean parallax published by van Rhijn (Gröningen Publication No. 34). It follows that the nearer stars dominate m.p. To find the relation between M (mean absolute magnitude) and H ($= m + 5 \log \mu$) a diagram is given, based on 181 stars, where $\mu = 0''{\cdot}3$ to $0''{\cdot}5$, and 325 stars where $\mu > 0''{\cdot}5$. These data represent m.p. up to $\mathrm{M} = 6{\cdot}5$, but the intrinsically faint stars deviate widely from it, and the luminosity function of Kapteyn and van Rhijn is applicable only for so long as we deal with stars whose magnitudes fall on the ascending branch of their curve. Their formula does not represent the parallaxes of low-luminosity stars whose mean parallax is nearly independent of m and is determined almost entirely by μ alone. The author urges the observation of every star of unknown or uncertain distance for which $\mathrm{H} > 7$. The physical significance of the investigation is whether stars fainter than about the 20th magnitude are so few as to be practically non-existent (as implied by the luminosity function of Kapteyn and van Rhijn), or whether the most frequent luminosity, and therefore the most frequent mass, of the stellar order is less than that of any known luminous star. The total number of low-luminosity stars may therefore be enormous. The data suggest that the total number of stars per cubic parsec brighter than M = 15 is about twice the total for all magnitudes found by Kapteyn and van Rhijn. A. S. D. M.

2703. *Observed Maxima and Minima of Variable Stars for* 1923. **L. Campbell.** (Harvard Coll. Obs. Circ. 259. pp. 1–8, 1924.)

2704. *Studies in Stellar Statistics.* **V. Michkovitch.** (Bull. Astronomique, 4. Ser. 2. pp. 9–142, 1924.) A summing up of Charlier's statistical methods and results. The first part gives theoretical investigations, of which one shows that the mathematical expression $y = e^{-h^2x^2} \times h/\sqrt{\pi}$, for Gauss's error curve, is only a particular case of a more general law. The author defines homograde and heterograde statistics, the latter constituting the most important work in the Charlier school. The whole theory of mathematical statistics is based on two forms, A and B, which the frequency function may take; these are developed, and their formulæ and numerical applications are given. In connection with the theory of correlations, great stress is laid upon the difference between functional and statistical correspondences. A statisti-

cal correlation does not imply a coordination between the data themselves (except when the coefficient of correlation = 1), but a relationship, more or less intimate, between the elementary errors of the two whole series of observations. In the second part of the paper the author obtains the fundamental equation of stellar statistics, $a(e) = \omega \int_0^\infty r^2 D(r) \phi(E) \partial E / \partial e dr$, where $a(e)$ is the total number of stars in the case considered, and e and E are the values characterising the apparent and absolute intensities of some property, which is supposed to vary from one star to another. Thus if we know the number of stars at distance r, we obtain the mean distance $\pi(e)$ of a star having the characteristic $er\frac{1}{2}de$, and he shows that the mean value of the parallax of stars having apparent magnitude m is equal to the product of the mean value of their proper motion and a constant factor. He examines Schwarzschild's ellipsoidal theory and Kapteyn's two-stream theory, and finds neither satisfactory from a statistical point of view. He gives Charlier's result for B-type stars, $r = R.10^{0{\cdot}2m}$ where r is the distance and R a constant parameter for stars of this class. He adds a table for stars of type O to N, giving the speed of the sun, mean distance and coordinates of apex, parameter R, absolute magnitude, density per cubic sir., size and position of the ellipsoid of velocities, and thickness in the Milky Way. The third part is an investigation by the author himself of 152 Algol-type stars, of which a table is given, concluding that these form a symmetrical system with respect to the Milky Way, the centre of gravity being situated at R.A. 20·8 h. and Dec. + 67°·2, at a distance of 2·46 sir. from our sun. A. S. D. M.

2705. *Early Observations of the Elliptical Disks of Jupiter's Satellites.* **W. H. Pickering.** (Harvard Coll. Obs. Annals, 82. No. 4. pp. 61–74, 1924.)—Satellites I, II, III and IV of Jupiter have such low densities that it is probable they are not solid bodies, but are composed of small particles closely congregated, like Saturn's rings. Satellite I rotates on its axis in 11 h. 55 m., the others in periods still unknown. All four appear to be prolate spheroids, the major axes exceeding the minor by about 10 per cent. Observations of these small bodies are important, chiefly because of their application to the laws of rapidly rotating ellipsoids, with special regard to the study of the evolution of spectroscopic binaries. The phenomena are readily visible in a 5-inch telescope, and have been independently discovered by over a dozen astronomers and confirmed by as many more; but doubt has been thrown upon their reality because excellent atmospheric conditions are necessary to show them distinctly. Such conditions occur very rarely at northern observatories, and large telescopes are more affected by bad seeing than small ones; hence the possessors of some of the world's largest telescopes have announced the disks to be always circular. Evidence of their ellipticity is here brought forward by the detailed publication of three series of observations, made at Arequipa in 1892–3, at Mandeville in Jamaica in 1901, and at the Lowe Observatory in California in 1904. Reference is also made to other series, published in the Annals of the Lowell Observatory, Arizona; and observations were made at Mandeville in 1912 and continued at nearly every apparition since that date. Belts have been seen on Satellites III, IV, and I, and drawings of all four have been made. M. A. E.

2706. *Catalogue for* 1875·0 *of* 1210 *Stars between Declinations* + 45° *and* + 90° *at Stockholm.* (Astron. Iakttagelser och Undersökningar, Stockholm, 10. 12. [32 pp.], 1924.)—1210 stars down to the 8th mag. were selected from the British Association Catalogue 1850·0 between the declinations + 45° and the pole, and observations of them were made with the meridian circle of 11 cm. aperture between the years 1873–1900. These were mostly finished by 1881, but lacunæ and outstanding observations were filled up from supplementary observations in the years 1888–90 and 1892–1900. To secure a precision of about 1/3″ in each coordinate, measures were made in each of four positions of the instrument, and for the years 1874–99 the error of a catalogue position was found to be in R.A. ± 0″·031, and in Dec. ± 0″·30 between 30° and 45°. For the reduction of the observations in R.A., the instrumental errors were not given by Bessel's formula, $t = m + n\,tg\,\delta + c\sec\delta$, but by $t = m + h\cot p + c\,tg\,\frac{1}{2}p$ (where p is the polar distance), in order to minimise the error of c in the case of stars near the pole. The positions in the Stockholm catalogue are compared with those of the catalogue of Astron. Gesellschaft. A. S. D. M.

2707. *Synopsis of Ionisation Potential of Elements.* **Cecilia H. Payne.** (Nat. Acad. Sci., Proc. 10. pp. 322–328, July, 1924.)—Two tables are given, one containing a summary of the best values assigned to the physical, spectroscopic or astrophysical ionisation potentials of the various elements; the second, a scale of stellar temperatures (somewhat higher than from other methods) for the reversing layers of the hotter stars, derived from the observation of lines corresponding to known critical potentials. From this, on the assumption that the partial electron pressure is constant at about 10^{-4} atmospheres, an estimation is made of the ionisation potential of any element, if its spectrum lines are known to have a maximum at a given stellar type, the astrophysical estimates being obtained by the author from a curve relating ionisation potential and temperature. A diagram is given showing the relation between ionisation potential and atomic number, the abscissæ being columns of the periodic table, and the ordinates ionisation potentials. From any one column to the next the slope of the line is similar in each period, and this uniformity is probably related to the similarity of electron orbit configuration for atoms in the same column. The ionisation potentials appear to change slowly in the long periods of classification, and this may be because the electron arrangement in the inner orbits change sensibly, but in the outer orbits change very little. [See Abstract 1162 (1924).] A. S. D. M.

2708. *Pressure in Stellar Reversing Layer and Origin of Solar Continuous Radiation.* **M. N. Saha.** (Nature, 114. pp. 155–156, Aug. 2, 1924.)—Estimates of pressure in stellar reversing layers range from 10^{-3} to 10^{-4} atmospheres [see Abstract 1810 (1923)]. The author suggests an accurate method for determining such pressures from the limit of series absorption of elements in the Fraunhofer spectrum. From the fact that Hζ is the last line seen in the Balmer series of H absorption lines in the Fraunhofer spectrum in the sun, though the flash spectrum has 35 Balmer lines, he infers that H(2) atoms in the particular layers treated lose their power of picking up pulses corresponding to the Balmer series, but exercise a sort of general enfeebled absorption on all radiation beyond Hζ, some-

what after the manner of X-ray absorption. This part will be freely emitted only by higher layers where the pressure is low enough ; in other words, if the solar atmosphere were composed of H(2) atoms only, part of the continuous spectrum beyond Hζ would originate from somewhat higher levels than the redder part of the spectrum. The argument holds good for other elements. Thus for different rays there are different photospheres, but the distance between the extreme red photosphere and the extreme violet one does not differ by as much as 100 km. The photospheres and reversing layers are intermingled, but the luminosity degrades rapidly in the concentric layers round the sun. The dark Fraunhofer lines are in reality intrinsically from 100 to 1000 as bright as the flash bright lines, and therefore an exposure which gives the Fraunhofer spectrum is too short to give the chromosphere ; the Fraunhofer absorption is caused by layers close to the disc, and the higher chromospheres is not effective here. The author applies the same conception to Alpha Cygni (a typical giant with 24 Balmer lines), to Sirius (a typical dwarf with 13 lines), and to Vega (intermediate between them with 17 lines) ; all show more Balmer lines than the sun, and this may be ascribed to the joint action of higher temperature and lower pressure. A. S. D. M.

2709. *Shrinkage of Stellar Mass through Radiation.* **H. Vogt.** (Zeits. f. Physik, 26. 2. pp. 139–142, 1924.)—According to Eddington [Abstract 1730 (1924)] there are only two possibilities : (1) Either stellar mass remains constant, in which case the Russell diagram has nothing to do with stellar evolution ; (2) or the diagram represents stellar evolution, in which case stellar mass must greatly diminish in the course of evolution. Double stars may supply a means of deciding which of these possibilities agrees with reality. If the second explanation be correct, then, following the course of the Russell diagram, we should find that the mean mass relation of the brighter to the less luminous components of double stars approximates more and more to unity. The author investigated the list of 85 double stars of known absolute luminosity and known spectral type contained in the Lick Observatory Bulletin No. 343, with the addition of the double stars referred to by Eddington and not included in the 85 systems. His investigations point to the conclusion that the Russell diagram represents stellar evolution and that, in the course of their evolution, stars diminish greatly in mass. E. F.

LIGHT.

2710. *The Colour of the Sea.* **R. Gans.** (Ann. d. Physik, 75. 1. pp. 1–22, Aug., 1924.)—Against the opinion of Rayleigh that the dark blue colour of the deep ocean may be explained by reflection of the blue sky, Raman has stated the molecular diffraction theory of sunlight, incident on the water particles, combined with the specific absorption effect of water itself.

This hypothesis has been further elaborated by Ramanathan (see Abstract 456 [1924)]. The present author now extends the latter theory still further, since the above authors have limited themselves to normal incidence, and thereby have only considered the scattering of light of the first order. Pencils of sunlight are now investigated for any angle incident on the water surface, whereby a fraction is reflected, the remainder penetrating into the water. Molecular diffraction then ensues, a portion being absorbed (*i.e.* converted into heat) and a residue returning as diffuse light to the surface, whereby a portion suffers internal reflection and the remainder passes out into the air. When the intensity of the incident light is assumed to be a function of the wave-lengths, the intensity of the diffused light may be calculated for every angle of emergence, the extent of polarisation entering as an additional problem. § 1 deals with scattering of the first order, from which it is concluded that the ocean sends out mainly diffuse light due to molecular diffraction, the blue colour of which is explained by the absorption of red, yellow, and green. § 2 contains a rigid formulation of the problem. The paper is mathematical throughout. H. H. Ho.

2711. *Algebraic Methods for the Calculation of Colour Mixture Transformation Diagrams.* **Clara L. Froelich.** (Optical Soc. of America, J. and Rev. Sci. Inst. 9. pp. 31–42, July, 1924.)—In the paper entitled "The Transformation of Colour Mixture Equations from One System to Another; Graphical Aids," by H. E. Ives [see Abstract 1105 (1923)], the methods of constructing the diagrams which constitute the final "graphical aids" are presented, for the sake of clearness, in graphical terms. Where, however, the highest accuracy is desired, and where facilities for performing computations rapidly are at hand, the construction of such charts is advantageously performed by algebraic means. It is the purpose of the present paper to explain this algebraic method, the object being (1) that it will be of general use, (2) that the algebraic methods developed for constructing these graphical aids actually constitute new modes of handling the transformations in question, which compare favourably in simplicity and accuracy with previously published purely algebraic treatments. § 1 shows how to transfer a working primary triangle to the unit-sensation-sum plane. § 2 describes how to inscribe equal purity lines in a colour-triangle plot of the spectrum. § 3 gives the application to the elementary sensation curves of Dieterici. Seven illustrative diagrams are included. H. H. Ho.

2712. *Optically Active Substances.* **R. Gans.** (Zeits. f. Physik, 27. 3. pp. 164–172, 1924.)—In continuation of previous work [Abstract 2405

(1923)], amending some of Born's formulæ [Abstract 934 (1918)], works out the refractive index, the circular polarisation, and the dispersion in optically active substances. A. D.

2713. *Absorption of Ultra-violet Rays by CS_2.* **G. Bruhat** and **M. Pauthenier.** (Comptes Rendus, 179. pp. 153–155, July 21, 1924.)—The curve of extinction-indices for various λ's, from 260 to 380 $m\mu$. A. D.

2714. *Scattering of Light by Very Big Colloidal Particles.* **W. Shoulejkin.** (Phil. Mag. 48. pp. 307–320, Aug., 1924. Paper communicated to the Sci. Soc. of Moscow, Nov., 1922.)—Reference is made to previous studies of this subject [see Abstracts 849 (1921) and 456 (1924)], in which the largest particles successfully dealt with are $\frac{1}{3}$ the size of the wave-length. The present study is limited to the case for particles having the ideal properties of a dielectric. A comprehensive mathematical exposition is developed, from which it is concluded that there is a smooth continuous change with increase of size of particle from scattering of light to its reflection and refraction. A relative index of refraction, $m = 1{\cdot}32$, is used throughout. With particles up to $\frac{1}{3}$ the wave-length in size, Rayleigh's formula and conclusions as to angle of complete polarisation are found to hold. From thence up to a diameter of particle equal to the wave-length definite asymmetry of dispersion is noted, the brightness of the scattered light in the direction of incident rays being 2·5 to 11 times greater than that in the opposite direction. Over this range polarisation is everywhere incomplete, but still in the same plane, the angle of maximal polarisation being displaced from 90° in the direction of the incident rays. With still larger particles the plane of polarisation becomes perpendicular to the plane of polarisation of Rayleigh's particles, this condition persisting over the range extending to particles infinitely greater than the wave-length, as also does the character of the distribution of dispersed energy. In limits with dimensions of particles infinitely greater than the length of the wave, the brightness of light scattered in the direction of incident rays is 52 times greater than the brightness in the opposite direction, the angle of maximal polarisation being 105° 40′. The variations in asymmetry of dispersion and polarisation effects are represented diagrammatically. A. B. C. L.

2715. *Anomalies of Accidental Double Refraction with Celluloid.* **A. Ramspeck.** (Ann. d. Physik, 74. 8. pp. 722–742, Aug., 1924.)—The modulus of elasticity of celluloid lies between 225 and 233 kg./mm.^{2}, the limit of elasticity with 1·5 per cent. extension, *i.e.* with a tension of about 3·5 kg./mm.^{2}. The double refraction $n_e - n_o$ within the limit of elasticity is proportional to the tension. Still, its magnitude depends on the amount of camphor present; the value of the specific double refraction decreases with increasing camphor content from 46×10^{-3} for no camphor to 5×10^{-3} with 50 per cent. camphor. The double refraction increases with the time with constant load, diminishes with constant extension, at first quickly, later always slower. Within the limit of elasticity the dependence upon time follows an exponential law. With repeated constant extensions the temporary decrease of the double refraction is always stronger; still, ordinary celluloid remains positive, double refracting up to 10 per cent. extension, while celluloid rich in camphor becomes negative, double refracting after repeated extension.

The dispersion of the double refraction in the cases observed, which did not extend far over the limit of elasticity, is very small. With feeble extension the dispersion is greater for blue than red, but, as the limit of elasticity is approached or exceeded, it is greater for red than blue. Thin sheets of gelatin show the same kind of dependence on the time with respect to double refraction as celluloid, but the dispersion is always in the normal direction. It is pointed out that on account of its anomalies, as here described, celluloid is not a suitable material with which to carry out experiments when it is wished to draw any conclusion on the distribution of inner tensions. A. E. G.

2716. *Refractivity and the Molecular Phase Hypothesis. I.* **E. C. C. Baly** and **R. A. Morton.** (J. Phys. Chem. 28. pp. 659–667, June, 1924.)—The Sellmeyer dispersion formula $n^2 - 1 = \frac{N}{\nu_0^2 - \nu^2}$ (where n = refractive index for light of frequency ν, N = constant, and ν_0 = characteristic frequency in the ultra-violet) does not agree with observed values if the substance exhibits an absorption band in the near ultra-violet as well as in the extreme ultra-violet. By an application of the molecular phase hypothesis a more complex formula is obtained which can be made to fit the observed values for chlorine, bromine, and ozone more nearly. W. V. M.

2717. *Experimental and Theoretical Researches on the Electromagnetic Birefringence of Active Bodies.* **R. de Mallemann.** (Ann. de Physique, 2. pp. 5–239, July–Aug., 1924.)—The study of electric or magnetic birefringence of bodies possessing rotatory power has now for the first time been made in an exact and systematic manner. Experimental difficulties have hitherto stood in the way of investigating optically active gases and vapours, while data for liquids have been obtained mainly in haphazard fashion by the usual methods for the determination of Kerr's constant for inactive bodies. The author now shows that the study of this hitherto neglected problem contributes usefully to the progress of knowledge upon molecular structure. The experiments of Kerr, Quincke, and Schmidt are first briefly reviewed. The work is then divided into two parts, of which the first is treated in three chapters, *viz.*: (1) Comprising the theoretical study of the phenomena resulting from the simultaneous observation of birefringence and rotatory power, whereby general formulæ are derived for their interpretation; (2) describing the general experimental methods employed; (3) containing the data obtained from a number of active liquid or dissolved bodies. This data indicates that the theory of exact superposition of the effects due separately to birefringence and rotatory power (Gouy's principle) gives in all cases the qualitative behaviour of the phenomena. The accord is also in general quantitative, sensible divergence only existing for very birefringent substances such as carvone, and even in this case the calculated ellipticities only differ from the observed by amounts within the limits of experimental error. These differences appear more systematic for axial rotations. In the particular case of carvone the behaviour is that of an increase of optical activity in a plane perpendicular to the electric field. It is established in every case that active bodies possessing true birefringence conform to Kerr's law. The study of ethyl tartrate has shown that the sensibility of its rotatory power to temperature is also found for its birefringence.

In the second part of the paper it is shown how the theory of molecular orientation admits, without fresh hypothesis, of the phenomenon of rotatory polarisation, being explained by the same molecular structure. The theory of orientation has shown that for very anisotropic molecules and fields sufficiently intense divergences between calculated and observed values may be observed due to the anisotropy of the rotatory power itself. The paper is so long and comprehensive as to merit being consulted in its entirety. H. H. Ho.

2718. *Research on Double Refraction in Moving Liquids.* **E. Krueger.** (Zeits. phys. Chem. 109. 5–6. pp. 438–452, 1924.)—Various liquids were examined, and it was found that double refraction never occurred unless the liquid shows the Tyndall phenomena under the ultra-microscope.
W. G. B.

2719. *The Kerr Electro-optic Effect in Gases.* **G. Szivessy.** (Zeits. f. Physik, 26. 4–5. pp. 323–342, 1924.)—For wave-lengths ranging from 486 $m\mu$ to 656 $m\mu$, it is shown that the magnitude of the double refraction due to an electric field (the Kerr effect) is, in the cases of the gases sulphur dioxide, ammonia, and carbon dioxide at atmospheric temperature proportional to the square of the field strength. In the case of each gas, the value of the Kerr constant is, for a definite wave-length, proportional to the pressure of the gas, and for any definite pressure is inversely proportional to the wave-length of the light employed, in accordance with Havelock's law. Values of Kerr's constant relating to a wave-length 589 $m\mu$ in the case of the gases at a pressure of 760 mm. of mercury were determined as follows at the respective temperatures given: sulphur dioxide, $1{\cdot}67 \times 10^{-10}$ at 17·3° C.; ammonia, $0{\cdot}59 \times 10^{-10}$ at 17·9° C.; carbon dioxide, $0{\cdot}24 \times 10^{-10}$ at 17·5° C. J. S. G. T.

2720. *The Verification of the Principle of Reflex Visual Sensations.* **M. S. Hollenberg.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 713–730, June, 1924.)—Allen's recent investigations on the effects of retinal fatigue upon colour sensations have led to the discovery of a new physiological reflex, which is sensory in its nature. Allen found that when light falls upon any part of either retina the perception of the three fundamental colour sensations, red, green, and violet, as measured by the critical frequency of flicker, is enhanced in both retinas. The experiments described in the present paper were carried out to ascertain if Allen's results applied to another normal individual. Over the whole of the spectrum examined, the author found that in every instance his curves were identical with those of Allen. The left eye was fatigued with various colours, and then the reflex effects upon the colour sensations in the right eye were measured, the latter being maintained in daylight adaptation. Similarly the right eye was treated when the left was maintained in daylight adaptation. The direct and reflex effects of white light and darkness were also studied, and theoretical discussions on the results obtained and also on some of Burch's experiments on fatigue are given, as well as a consideration of the brief initial overshooting of sensations when coloured light is first applied to the eye. The experimental results support the trichromatic theory of Young and Helmholtz. One striking feature especially noticeable is that while the luminosity of violet of wave-

length 0·410 μ is about $\frac{1}{700}$th of that of yellow, 0·589 μ, the depressions produced by the latter colour are but slightly greater. This shows that the magnitude of the reflex effect is not a direct function of the physiological brightness of the stimulus. J. J. S.

2721. *Reflex Visual Sensations and Anomalous Trichromatism.* **W. A. Anderson.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 731–765, June, 1924.)—After a brief summary of the principle of reflex visual sensations as discovered by Allen, the author, who has abnormal vision, gives an account of the determination of the character of these reflexes for such vision. The experiments were performed in a daylight room, using the critical frequency of flicker method. The quantitative results were obtained by making measurements on pure spectral colours. Abnormal vision is shown by the character of the persistency curve taken under normal conditions of daylight adaptation. The type of curve, which was the same for both eyes, is compared with one for normal vision and one for partial colour-blindness. Next the left eye was fatigued, and measurements made of the changes in the visual response of the right to light from the different parts of the spectrum. The change in the response was always an enhancement of the brightness of the affected colours. Red and green were more susceptible to this reflex enhancement than the violet. Certain colours—0·660 μ, 0·505 μ, 0·425 μ, and the entire region 0·520 μ to 0·480 μ—showed no reflex transferred to the other eye. The magnitude of the reflex was greatest for fatiguing colours near the ends of the spectrum. The effect of dark adaptation was transferred to the other eye similarly to fatigue. The red sensation was found to be difficult to fatigue, but very susceptible to enhancement. The behaviour of the violet was the reverse of this, while green exhibited an intermediate character. No effect was obtained for fatigue colours 0·665 μ, 0·589 μ, 0·570 μ, and only a small effect for 0·520 μ. The effects of darkness and strong white light are very similar, both showing fatigue characteristics. The results obtained show that every ray of light produces both a direct and a reflex effect upon all three fundamental sensations, which are shown to be red, green, and violet. The author's type of colour-vision is that of an anomalous trichromat. By means of the principle of visual reflexes the Young-Helmholtz and Hering theories are harmonised, and can no longer be regarded as rival hypotheses. [See preceding Abstract.] J. J. S.

2722. *Selenium Optical Densimeter.* **E. V. Hjort, A. Lowy** and **O. Blackwood.** (Optical Soc. of America, J. and Rev. Sci. Inst. 9. pp. 43–51, July, 1924.)—The relative absorptions of different substances for red and, in a less degree, for orange light may be measured by the variations of the galvanometer readings in a circuit containing a suitable selenium cell. Experimental methods and data. A. D.

2723. *High-Power Transparent Illumination for Microscopes.* **C. Beck.** (Journ. Sci. Instruments, 1. pp. 314–316, July, 1924.)—A continuation of previous papers on microscope illumination [see Abstracts 1136 and 2049 (1924)]. The author points out that with transparent illumination, where the object is only visible by reason of the contrast which its edges or internal structural details present as compared with the bright background, any light which falls upon the object from the observer's side—

e.g. light reflected by the cover-glass—is detrimental to the observation of delicate structure. Objects whose refractive indices are different from that of Canada balsam, or which are visible owing to coloration, may be mounted in this substance so that back reflection from the cover-glass is avoided. In other cases the best method of reducing glare is to use a small source of illumination and to produce a still smaller image of this source upon the object by the substage condenser, so that as small a portion of the object as possible is illuminated. Methods of achieving this in practice are described in the paper. J. W. T. W.

2724. *The Radiometer.* **A. Einstein.** (Zeits. f. Physik, 27. 1. pp. 1–6, 1924.)—Assume gas of indefinite extent; a heat-flow along the axis of x; gas-molecules have one velocity, u, parallel to the axes of coordinates only; the mean free path, λ, is a constant. Set up a small element of surface, area σ, at right angles to the heat-flow; let this be small in comparison with λ; there should be no flow of material across this; an equal number, ν, of molecules should pass each way; $\nu = n\sigma u/6$. For the flow of heat, u must be slightly different on the two sides; u_+, u_-; the flow of heat per second is $\sigma f = \frac{1}{6}n\sigma u \,.\, (\frac{1}{2}mu_+^2 - \frac{1}{2}mu_-^2)$. But $\frac{1}{2}mu_+^2 = \frac{3}{2}k\mathrm{T}_+$, $\frac{1}{2}mu_-^2 = \frac{3}{2}k\mathrm{T}_-$, the T's being the absolute temperatures at the ends of the free path λ; $\therefore$ the flow of heat per second per unit of area is $f = \frac{1}{4}nuk \,.\, (\mathrm{T}_+ - \mathrm{T}_-) = \frac{1}{4}nuk \,.\, \lambda(\partial\mathrm{T}/\partial x) = -\frac{1}{4}(pu\lambda/\mathrm{T})(\partial\mathrm{T}/\partial x)$; note, the author says $-\frac{1}{2}$ for $-\frac{1}{4}$. Now take a small body of transverse area σ; the molecules impinging per second communicate an aggregate impulse $\frac{1}{6}n\sigma u \,.\, (mu_+ - mu_-)$; if u_+ and u_- be very nearly equal to u, this may be written $\frac{1}{6}n\sigma \,.\, (mu_+^2 - mu_-^2) = f \,.\, (2\sigma/u)$; note, the author writes $\sigma f/u$. But this represents the force F acting on the small body;

$$\mathrm{F} = 2\sigma f/u = -\tfrac{1}{2}nk\sigma\lambda(\partial\mathrm{T}/\partial x) = -\tfrac{1}{3}p(\lambda/\mathrm{T})(\partial\mathrm{T}/\partial x)\sigma;$$

the author's result. If the small body be free to move, it is set in motion with some velocity v; at velocity v it is subject to gaseous friction F'; it communicates to each molecule impinged on by it an impulse mv; $\mathrm{F}' = -\frac{4}{3}n\sigma u \,.\, mv$. For a steady velocity v, make $\mathrm{F}' = -\mathrm{F}$; then $v = -\frac{3}{8}p\lambda(\partial\mathrm{T}/\partial x)/\mathrm{T}num = -\frac{1}{8}n\lambda(\partial\mathrm{T}/\partial x)/\mathrm{T} = \frac{1}{2}f/p$; note, the author writes $v = \frac{1}{4}f/p$; $\therefore$ if the body be small in comparison with λ, the steady velocity v is independent of its size.

For a small hole in a screen placed transverse to the heat-flow.—Let the screen be large in comparison with λ, and so also the distance between its rim and the bounding walls; in spite of the heat-flow there will be an equilibrium of pressure. Let ν_n molecules per cm.^{2} per sec. come from the left with a velocity u_n, strike the screen, and return with a velocity u; and similarly on the other side ν_p, u_p, u. For pressure-equilibrium, $p/m = \nu_n(u_n + u) = \nu_p(u + u_p)$. For heat-flow the same on both sides of the screen, $2f/m = \nu_n(u_n^2 - u^2) = \nu_p(u^2 - u_p^2)$. Therefore $2f/p = u_n - u = u - u_p$.—In $\nu_n = nu_n/6$, assume ν_p very nearly equal to ν_n and write as $\frac{5}{2}\nu_p - \frac{3}{2}\nu_n = \frac{1}{6}nu_n$ or $2(\nu_p - \nu_n) = \frac{1}{6}nu_n - \frac{1}{2}(\nu_p + \nu_n)$. Assume $\frac{1}{2}(\nu_p + \nu_n) = \nu_m = \frac{1}{6}nu$; then

$$2(\nu_p - \nu_n) = \tfrac{1}{6}nu_n - \tfrac{1}{6}nu = \frac{n}{6}(u_n - u) = \frac{n}{6} \cdot \frac{2f}{p}$$

i.e. $\nu_p - \nu_m = \frac{1}{6}n \,.\, f/p$.—Through a small hole, area σ, the excess of molecules travelling negatively with regard to the axis of x is, per

second, $(\nu_p - \nu_n)\sigma$; but $(\nu_p - \nu_n) = n(-v)$; $v = -(\nu_p - \nu_n)/n$, $= -\frac{1}{8}f/p$.

For denser gases.—A screen large in comparison with λ; its rim at a distance from the bounding walls also large in comparison with λ. At a sufficient distance from the rim (*a*) centrewards there is pressure-equilibrium at the screen; (*b*) outwards we have $F = \sigma f/u$ (*sic*) on a small body. At the rim there is a transition, say about λ in breadth, and there is a force per unit of length of the rim, of the order $F = (\lambda/u)f$. [Proof not given.] For a screen heated on one side, the working out [not given] is somewhat difficult; the author finds for the rim, per unit of its length, an expression

$$F = -p\lambda\frac{\Delta . T}{T}.$$

Besides these we have the thermal slip. [See next Abstract.] A. D.

2725. *The Radiometer.* **G. Hettner.** (Zeits. f. Physik, 27. 1. pp. 12–22, 1924.)—When along the surface of contact between a gas and a solid there is a temperature-gradient, the gas flows from regions of lower to regions of higher temperature. This thermal slip was predicted by Maxwell and independently deduced and verified by Knudsen. The consequences of this slip serve to explain a large group of radiator phenomena. A. D.

2726. *An Experimental Study of Grating Errors and "Ghosts."* **R. W. Wood.** (Phil. Mag. 48. pp. 497–508, Sept., 1924.)—The work described in this paper was undertaken in the course of a study of the problem of making short-focus concave gratings for vacuum spectrographs. The cause of the Lyman "ghosts" has been ascertained experimentally, and an attachment added to the Rowland dividing engine which has abolished them completely. An optical method of studying the errors, periodic and otherwise, of gratings has been developed, and is now fully described, which can be applied to any grating, either plane or concave. This method, while lacking some of the advantages of the method of cross-ruling, first suggested by Rayleigh and employed by Rowland, is more sensitive than this, and will show the effect of two or three slightly misplaced lines, or a grating ruled with 15,000 lines to the inch. Experimental data have been furnished which make it possible to visualise the manner in which the "ghosts" or spurious lines are produced when a periodic error of ruling is present in the grating. Reproductions are given of the photographic records obtained with a small concave grating of 1 metre radius, ruled with 15,000 lines to the inch. The periodic error is found to have impressed upon the wave-front a condition similar to that produced by its passage through a coarse grating acting by opacity. The question of the Lyman "ghosts" is dealt with at length. These were found to be due to two periodicities in addition to the normal periodic error. The paper concludes with an account of metallised glass concave gratings, and a description of a circular target pattern obtained when short-focus concave gratings are examined by reflected light. The latter shows how the intensity distribution among the various orders varies with the part of the diamond edge used for the ruling. H. H. Ho.

2727. *Designs for Telescopic Adjustments enabling Variable Magnification.* **L. Dunoyer.** (Rev. d'Optique, 3. pp. 353–397, Aug., 1924.)—Terrestrial telescopes fitted with suitable adjustments have the advantage over the prismatic type with multiple ocular that it is possible to vary the

magnification in a continuous manner between certain limits. To accomplish the latter object, the movable attachment consists of two converging lenses which simultaneously undergo appropriate displacements. The present paper investigates different movement combinations, based on the focal data, which may be adopted for the added lens system, both for movements in like and opposite senses, thereby fixing the respective attainable maximum and minimum magnifications. By these means suitable combinations are derived and distinguished from unsuitable, whereby the magnification may be varied within considerable limits. The complete numerical discussion of the problem includes the magnification curves for 47 combinations, knowledge of which enables, by suitable interpolation, the choice of combination of any desired type. The paper is entirely mathematical, and should be consulted in its entirety. H. H. Ho.

2728. *Large Objective at Strasburg Observatory.—Defects in Hartmann's Method of Testing.* **A. Danjon.** (Rev. d'Optique, 3. pp. 305–314, July, 1924.)—This objective, by Merz, is of 486 mm. effective diam. and works at an aperture $f/14$. It has always shown an undesirable amount of astigmatism and has been subjected to a thorough examination. As a result, the crown has been turned through an angle of 60° in its mounting, and the performance has been much improved. It now shows a residual spherical aberration at the central portion. A focogram shows a number of local defects which can be remedied by retouching. These are missed by the Hartmann method, and the author emphasises the importance of including the taking of a focogram as a necessary part of the tests of any large objective. J. W. T. W.

2729. *Lens for Whole-Sky Photographs.* **R. Hill.** (Roy. Meteorolog. Soc., J. 50. pp. 227–233; Disc., 234–235, July, 1924.)—In discussing the production of photographs of an angle of view of 180°, comparison is made of the effects obtainable by the pinhole method ($\phi = \theta$), the stereographic projection method ($\tan \phi/2 \div \tan \theta = \text{constant}$), the equidistant method, ($\phi/\tan \theta = \text{constant}$), and the orthographic projection method ($\sin \phi/\tan \theta = \text{constant}$); ($\phi$ and θ = the angles to the axis made by any ray outside and inside the camera respectively). A lens system on the basis of equidistant projection is described resembling a telephoto arrangement reversed, and illustrations are given of cloud photographs obtained by its use. These whole-sky projections may, by reversing the action of the lens, be converted into sectional photographs wherein the curvature is rectified. In reply to discussion, the author indicates that the present form of lens can only be used when the light is comparatively good, and that its rapidity would have to be increased to enable it to be used in photographing aurorae. A. B. C. L.

2730. *Optical Rate-of-Climb Recorders: their Uses, Theory and Description.* **A. H. Mears** and **D. H. Strother.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 787–801, June, 1924.)—The instruments described were developed by the staff of the Bureau of Standards for the American Services. In an introductory note, the design requirements are outlined for rate-of-climb instruments for lighter-than-air and also for heavier-than-air craft. The effects of position error (*i.e.* change of reading caused by tilting), mechanical shocks and vibrations are also considered. The five available methods for determining rate of climb are

enumerated and their merits and disadvantages are discussed. The authors appear to favour the use of a rate-of-climb recorder, as it does not require the attention of an observer, and in conjunction with an accurate barograph gives all the information required. The uses of rate-of-climb instruments are dealt with. The principle of operation of leak-type rate-of-climb instruments is considered, and it is pointed out that for correct functioning the flow of air through the leak device must be non-turbulent. The theory of the leak-type instrument, with non-turbulent flow, is worked out from considerations of altitude and isothermal air conditions, and a formula is given for the rate of change of height with time, as follows :—

$$\frac{dZ}{dt} = -\left[\frac{K_1\rho_0\pi r^4}{p_0 8l\mu}\right]\Delta p,$$

where Z = isothermal altitude, p the pressure on the system at this altitude, r the radius of the capilliary leak tube, Δp the pressure difference between the two ends of the capilliary tube, l the length of tube, μ the viscosity coefficient of the air at the existing temperature, ρ_0 the density of the air in the air chamber at an isothermal altitude Z_0, and a corresponding pressure p_0. K_1 is a constant. The experimental and the first and second optical types of Bureau of Standard's rate-of-climb recorder are described. The latter is stated to give excellent records, and to have a sufficiently open scale to record small changes in rate of climb. A sylphon diaphragm is used, in connection with a capilliary leak tube, and the deflections of this compound metal diaphragm are recorded optically on a continuously moving strip of film. The source of light is a 2·5-volt single filament bulb, worked off two small flashlight cells. A. W. J.

2731. *A Combined Illuminometer and Reflectometer.* **G. A. Shook.** (Optical Soc. of America, J. and Rev. Sci. Inst. 8. pp. 803–805, June, 1924.)—A description of an instrument which is essentially an illuminometer and may be used like any illuminometer, but is so designed that when used in connection with an integrating sphere it becomes a portable reflectometer. Details of construction and calibration are given.
W. V. M.

2732. *The Lummer-Gehrcke Parallel Plate Interferometer.* **F. Simeon.** (Journ. Sci. Instruments, 1. pp. 296–304, July, 1924.)—Notwithstanding the publication of many papers dealing with the theory and use of this instrument, a number of points in the elementary theory seem insufficiently appreciated, so the paper gives a brief consideration of these to help in the choice of a suitable size of plate and in the interpretation of the appearance it gives. Simple approximate expressions are given for the order of the spectrum, separation of consecutive orders, dispersion, and resolving power, together with notes upon methods of use, the appearances obtained and the interpretation of these appearances. A few precautions to be observed in order to obtain the finest definition are also noted, *viz.* avoidance of inequality of temperature throughout the plate, cleanliness of plate surfaces, and use of a suitably disposed polarising prism to obtain fullest resolving power. A complete bibliography of the Lummer-Gehrcke plate is given which includes 39 references. H. H. Ho.

2733. *Reflection of Plane Polarised Light by Etched Metals.* **O. Jones.** (Phil. Mag. 48. pp. 207–216, July, 1924.)—Plane polarised light was

reflected normally from an etched metal surface and the reflected light analysed by a Nicol prism. The intensity of the light changes as the metal surface is rotated in its own plane. Using white light or mercury arc lamp as required the light reflected from the polished part of the surface was extinguished by suitable arrangement of the analyser, *i.e.* "crossed Nicols." The etched parts then exhibit different degrees of brightness according to the orientation of the crystal. Each crystal, in rotation through 360° in its own plane, gave four maxima and four minima positions, and if the analyser was turned through 90° two maxima and two minima are shown. By means of high magnification (up to 1800) a fine striated structure of the surface was distinguished. It is suggested that the maxima and minima are due to similar orientation of the parts making up any one crystal grain. This regular orientation is developed by etching into a ridged or furrowed structure of the surface, producing the striations visible under high magnification. Light incident normally on the surface of such an etched specimen is returned, therefore, after two reflections, one at each side of the furrow. The polarised state of such light is shown to account for the maxima and minima. Confirmatory tests were made with large-scale models of furrows and also by examination of the scratchings and rulings of a metallic grating. Steel, containing pearlite and ferrite, bronze, aluminium and various alloys, were tested and the results are incorporated. S. G. B.

2734. *On the Polarised Fluorescent Light from Dyestuff Solutions. III.* **W. L. Lewschin.** (Zeits. f. Physik, 26. 4–5. pp. 274–284, 1924.)—The polarisation of the fluorescent light from dyestuff solutions was discovered by Weigert and further investigated by the present author and S. J. Wawilow. [See Abstract 1847 (1923).] This paper continues the earlier work, and deals especially with the influence of dyestuff concentration, wave-lengths of the exciting light, and temperature upon the polarisation. The concentration was varied from 10^{-3} to $3 \cdot 10^{-7}$g./cm.^{3}, and increase of concentration found in all cases to be accompanied by a decrease in the extent of polarisation. The latter, however, is partially to be explained by the appearance of secondary fluorescence. Tables of data are included. The influence of wave-length was not discovered to be a general phenomenon, two cases only being found out of four dyestuffs investigated, when the degree of polarisation increased with the wave-length. It is now shown for the case of rhodamine B extra, which earlier was found to behave as an exception, that the same polarisation limits are attained with small concentrations as for the other dyestuffs. Temperature is found to exert a special depolarising effect on the fluorescent light quite apart from the indirect influence through change of viscosity of the solvent. The dyestuffs investigated were fluorescein, rhodamine B, roduline red B, Magdala red, erythrosine and rose Bengal. A supplementary note discusses a recent paper by Gaviola and Pringsheim [Abstract 2263 (1924)]. H. H. Ho.

2735. *Polarised Fluorescence in Colour Solutions.* **F. Weigert** and **G. Käppler.** (Zeits. f. Physik, 25. 2. pp. 99–117, 1924.)—It is shown that the fluorescent light emitted from water solutions of fluorescein, when radiated by plane polarised light, is not markedly polarised for small concentrations of the colouring substance. As the concentration increases, however, the polarisation of the fluorescent light increases. In glycerine

solutions, on the contrary, the polarisation in a weak solution may be 30 % whilst in more concentrated solutions practically no polarisation can be observed. The viscosity of the fluorescent medium has only a secondary influence on the degree of polarisation of the fluorescent light.
A. B. W.

2736. *Interference by Diffusion.* **F. Wolfers.** (Comptes Rendus, 179. pp. 262–263, July 28, 1924.)—A mechanism is suggested to explain the results previously described [Abstracts 2197 (1923) and 2053 (1924)]. It is supposed that at the surface of all bodies resonators exist capable of absorbing energy quanta and of re-emitting them in the form of spherical waves. By reason of the field which exists at the free surface of solids and of liquids, these resonators should be oriented conformably to the ideas of quantification in space. The fields in question appear to be very intense, as in no case was it found that the phenomena observed were modified by the application of strong external fields. If each point of the source acts on the resonators independently of the neighbouring points the phenomenon could not be observed, an infinity of systems of fringes being then superposed. This difficulty can be overcome by supposing that the oriented resonator, if it receives simultaneously waves coming in directions contained within a certain small solid angle, integrates in some way the effects received, and diffuses a simple spherical wave capable of interfering with the direct waves. A. W.

2737. *Methods for the Determination and Measurement of the Aberrations of Optical Systems.* **L. Lenouvel.** (Rev. d'Optique, 3. pp. 211–243, May, and pp. 315 333, July, 1924.)—This very comprehensive investigation is described in four parts. Part I considers the experimental arrangements in detail which have enabled the determination of aberrations of optical systems, and is prefaced by a brief discussion of the principles involved.

Part II gives a geometrical study of the experimental data. A comparison between the measured and calculated aberrations for the case of a simple lens has confirmed the accuracy of the author's deductions. These geometrical considerations are then applied to the study of two types of objective, the simple achromatic and the anastigmatic.

Part III deals with certain phenomena in connection with fringes which are not considered in Part II. The application of the diffraction laws shows that the above are due to interference, and the present investigation enables the limits to be defined within which the laws of geometrical optics may be applied. The method is also shown to render very accurate results if very fine fringes be examined. The experimental arrangement adopted for the study of ordinary objectives is not conveniently applicable to those of short focal distance, and Part IV contains an account of the modifications necessitated for this purpose. The paper contains 49 illustrations. H. H. Ho.

2738. *Cinematic Study of the Working of Optical Surfaces.* **C. Dévé.** (Rev. d'Optique, 3. pp. 108-126, March; 157 174, April; 257-269, June; and pp. 334-341, July, 1924.)—These four communications describe exhaustively an investigation of the simple and compound movements required with respect to the working of glass surfaces and the tools employed. Part I is limited to plane surfaces, and gives details of a method

for obtaining uniform abrasion in which the glass is made to turn at the same speed as the tool which is gradually displaced upon it. Adjustments for variations in the amount of grinding and for the production of desired edges are also discussed. Part II considers spherical surfaces. The positions of the instantaneous axes of rotation for equality of abrasion at the centre and for two or three concentric annuli are determined, together with calculations for the necessary rotation speeds of glass and tool. Sub-sections discuss choice of course, glasses which swerve from the tool, requisite characteristics of a machine for ensuring uniform abrasion, etc. Semi-automatic machines for small surfaces of high curvature are described in the third paper as a continuation of Part II, together with their manipulation and the testing of the surfaces produced. Systematic adjustments are detailed for obtaining spherical surfaces of radius slightly different from that of the tool. Part III deals with non-spherical curved surfaces, and describes the requisite mechanical arrangements for their production. Practical workshop rules are included throughout the paper, which contains 26 illustrative diagrams. H. H. Ho.

2739. *Fraunhofer Diffraction Phenomena.* **J. Barnes.** (Optical Soc. of America, J. and Rev. Sci. Inst. 9. pp. 77–79, July, 1924.)—Shows how to demonstrate diffraction and interference phenomena with the aid of small pieces of the screens ruled by Max Levy & Co. for half-tone reproduction work. A. D.

2740. *Diffusion of Light by Kr and Xe.* **J. Cabannes** and **A. Lepape.** (Comptes Rendus, 179. pp. 325–327, Aug. 4, 1924.)—Perfectly pure gases used. The depolarisation of the light diffused transversely came to 0·0055, an amount which does not vary from argon to xenon. Under the same conditions as to temperature and pressure, krypton diffuses 1·95 times as much as air, and xenon 5·45 times. A. D.

2741. *First Law of Photochemistry.* **Muriel C. C. Chapman.** (Chem. Soc., J. 125. pp. 1521–1526, July, 1924.)—A detailed description is given of experiments carried out to determine the effect of variation of intensity of light on the rate of combination of H and Cl. With intensity ratio 1·6 ratios of rates of combination are found variously 1 : 5·49 and 1 : 5·67, which is not in agreement with results obtained by Baly and Barker, where an intensity ratio 1 : 6 corresponds to a combination rate 1 : 10. The deviation from Draper's law, that the amount of chemical change in a given system effected by light of a specified wave-length is proportional to the light absorbed, is ascribed either to the temporary reduction in the pressure of the water-vapour occasioned by the formation of HCl, or to a slight inhibitive effect of the HCl itself. The opinion is expressed that the results demonstrate the validity of Draper's law almost conclusively, even in the case of the photochemical change which exhibits the greatest departure from Einstein's law of photochemical equivalence. A. B. C. L.

2742. *History of the Photographic Objective in England and America between* 1800 *and* 1875. **M. v. Rohr.** (Phot. J. 64. pp. 349–359; Disc., 359, Aug., 1924.)

2743. *The Demonstration of Stationary Light Waves as a Lecture Experiment.* **K. Leistner** and **W. Möbius.** (Ann. d. Physik, 74. 8. pp. 700–

702, Aug., 1924.)—The original Wiener experimental demonstrations of stationary light waves are unsuitable for lecture experiments, because they admit of no immediate observation of the interference bands, while the presentation of the photographic active film is not simple. Previous methods are referred to, *e.g.* of Drude and Nernst, which employs the fluorescence effect of ultra-violet light, and of Selenyi, which replaces the photographic film by one of small sulphur particles, and so renders visible the maxima of the stationary waves. The complex character of the latter phenomenon is discussed. The previously described experiment of Leistner [see Abstract 2255 (1924)], in which disturbance is avoided both from Newton and Selenyi bands, requires too much time for lecture purposes. The authors now demonstrate that the Selenyi method, with suitable modifications obtained by a combination of Wiener and Selenyi details, serves excellently for a rapid and simple experimental proof of the existence of stationary light waves. The validity of the phenomenon observed is discussed at length. H. H. Ho.

2744. *Fluorescence.* **A. Gyemant.** (Zeits. f. Physik, 26. 4–5. pp. 223–234, 1924.)—A simple method for measuring the intensity of fluorescent light from solids, applicable also to measuring the intensity of fluorescence-exciting radiations, such as Röntgen rays. Full description of two types of apparatus. A. D.

2745. *The Reflection of Characteristic Bromine X-Radiation by a Crystal of Potassium Bromide.* **S. K. Allison** and **W. Duane.** (Nat. Acad. Sci., Proc. 10. pp. 298–302, July, 1924.)—The X-ray spectrum was produced by reflecting the radiation from a molybdenum target tube by the 100 planes of the crystal, using an ionisation spectrometer, and the results are shown in a graph. In a table the probable source of each maximum is given, together with the wave-length. In the first order the molybdenum K series peaks are prominent, a discontinuity of the curve due to the critical absorption of Br can be seen, and faint evidence of the peak corresponding to the Kα radiation of bromine was obtained. The second order Brα(2) peak is clearly seen. The γ and β peaks in this order fall so near to Moγ(3), third order, that they cannot be distinguished. Brγ(3) and Brβ(3) are separated and quite unmistakable; this separation shows that the phenomenon cannot be due to absorption followed by a decline in intensity, as suggested by some authors. Brα(3) can just be distinguished, though it nearly coincides with Moγ(5). H. N. A.

2746. *Chemical Affinity and Infra-red Spectra.* **A. Balandin.** (Zeits. f. Physik, 26. 2. pp. 145–160, 1924.)—Salts have two free vibrations in the infra-red. The heats of formation fall off with increasing differences between these two vibrations. An attempt is made to extend Kossel's molecule-model so as to make it present periodic critical values. A. D.

2747. *Magnetic Field and Polarisation of Canal-Ray Light.* **R. v. Hirsch.** (Phys. Zeits. 25. pp. 333–335, July 1, 1924.)—For fields below 1500 Gauss, the results of Abstract 893 (1916) confirmed as regards the line H_γ; but H_α and H_β are already strong and are not strengthened by the magnetic field. At the same time the light is not weakened by the magnetic field, as it was in the earlier experiments. Above 1500 Gauss the polarisation falls off for all three lines and disappears at about 2400 Gauss. A. D.

2748. *Faraday Effect.* **W. Gerlach.** (Zeits. f. Physik, 26. 2. pp. 143–144, 1924.)—M. Holmes's new phenomenon of retardation in the magneto-optic Faraday effect [Abstract 68 (1924)] traced to physiological causes. A. D.

2749. *The Paschen-Back Effect in the H Atom.* **H. Falkenhagen.** (Zeits. f. Physik, 28. 1. pp. 1–10, 1924.)—To explain Oldenberg, Försterling and Hansen's data [Abstract 530 (1924)] as to the magnetic splitting of H_α and H_β lines, one possibility seemed to be that, preserving the Bohr H-atom, the nucleus is mobile and the masses of the nucleus and the electron variable in terms of relativity. Calculation does not give the required effect, so that it becomes necessary to investigate unconditioned periodic systems and to find a quantising for these. A large field of new work is thus opened up. A. D.

2750. *Application of the Oun to Series Grouping.* **W. M. Hicks.** (Phil. Mag. 48. pp. 321–348, Aug., 1924.)—A defence of the oun, together with an application to the discussion of the spectrum of manganese. It has been suggested that, as the oun depends on atomic weights and not atomic numbers, it can have no natural significance in view of the discovery of isotopes. The usual "atomic weight" is taken to be a statistical mean of the atomic weights of the isotopes present; the ratio of the numbers is a definite one, and independent of the source from which the element is taken. So in the building up of an element there must be some cause, depending on the constitution of the element itself, which decides in what proportion each isotope shall be formed. If this cause also affects the doublet and triplet separations, then the oun will depend on the observed atomic weight. Paschen's scheme for Al I, Al II, and Al III are used to illustrate the constancy of the oun. The series scheme for manganese suggested by Catalán is compared with that due to the author. Catalán finds that the spectrum can be arranged into series of triplets and quintuplets; the triplets are unaccompanied by the usual singlet series, but in their place is another set of narrow triplets. These can be considered as split and displaced singlets ("collaterals") or as independent triplets. The evidence for these two hypotheses is sifted in the light of the oun, but the result is inconclusive. A. C. M.

2751. *The Intensity Distribution of the Components of H_α.* **E. Gehrcke** and **E. Lau.** (Ann. d. Physik, 74. 6. pp. 574–576, July, 1924. From the Reichsanstalt.)—The intensity distribution of a single line is determined by the Gaussian "curve of error" if it is assumed that the principal factor in the variation is the Doppler effect of the emitting atoms. The "curve of error" is represented by $J = 2^{-(\delta\lambda)^2/10}$, and it is found that the hydrogen line H_α shows an intensity variation which agrees with this formula, where J is the intensity and $\delta\lambda$ the difference between the wave-length under consideration and the mean wave-length. This evidently implies that under the conditions employed each component is determined by the Doppler effect. W. V. M.

2752. *Heat-Equilibrium in Radiation Field in Presence of Matter.* **S. N. Bose.** (Zeits. f. Physik, 27. 5–6. pp. 384–392, 1924.)—The probability calculated for a system consisting of radiation and molecules, and the conditions for statistical equilibrium determined. New expressions found for the statistical probability of elementary processes involving reciprocal

actions of radiation and matter. Criticism by **A. Einstein** (*ibid.* pp. 392–393, 1924). A. D.

2753. *The Emission of Radiation from Platinum.* **M. Czerny.** (Zeits. f. Physik, 26. 3. pp. 182–189, 1924.)—If the radiation from incandescent metals be examined it is found that at small angles of emission the radiation is, to a large extent, linearly polarised. According to theory, it is expected that this behaviour occurs to a particularly large extent in the infra-red radiation, and at this point it almost approaches complete linear polarisation. The experiments recorded were made to establish, by measurement, the above theory for platinum, using a wave-length $\lambda = 6{\cdot}8\ \mu$. The source of radiation used was a platinum plate 26 cm. long, 3·1 cm. wide and 0·072 mm. thick, which was maintained electrically heated by an alternating current at a temperature of 850° C. The plate was supported horizontally, and was capable of rotation to any known angle about a horizontal axis. After passing through a special light filter to absorb the longer wave-lengths, the radiation passed through a slit, arranged of such width as to exclude all radiation from the edges of the platinum plate and only admitting a uniform beam. A shutter behind this slit served to interrupt the passage of the radiation. A mirror system, including a spherical mirror, brought the beam to a focus on a second slit of such width as to limit the beam to radiation which emerged from the first slit to an angle of $\pm\ 0{\cdot}5°$ in the vertical and $= 1°$ in the horizontal directions. The radiation then passed through a Pfund polariser [John Hopkins Univ. Arc. 1906, vol. 4, p. 13] rotatable about its axis of length. The rays then are successively incident on three calc-spar plates, and finally are brought to a focus on a microradiometer by means of a second spherical mirror. The calc-spar reflectors give a wave-length of $\lambda = 6{\cdot}76\ \mu$ to the radiation. The detailed experimental procedure is recorded, and a table of results for the ratio E_s/E_p is given. This ratio shows the relative manner in which the radiation is emitted from the Pt strip according as the electrical vector swings horizontally or vertically, and thus is the ratio of emissivity coefficients. A comparison is effected between the results obtained experimentally and thus calculated from the metallic reflection formula $n.K = 5{\cdot}48\sqrt{\lambda/\omega}$, where ω is the specific resistance at the chosen temperature, $n = 23{\cdot}14$, and $K = 1$. The agreement is tolerable, and the results confirm the theoretical expectation. A discussion of the discrepancies is given and possible explanations suggested. The determination of the intensity of radiation is also accomplished by utilisation of the results obtained with this apparatus. The paper concludes with a discussion of the relative merits of various sources of radiation, and compares these with the type of Pt strip used in these experiments. S. G. B.

2754. *The Output of Radiation from the Quartz Mercury Arc during the Period after First Striking.* **B. D. H. Watters.** (Phil. Mag. 48. pp. 527–534, Sept., 1924.)—The variations of output during the time taken by a mercury arc to reach its steady state were measured by successively exposing a strip of gelatino-chloride paper (P.O.P.) every 30 secs. to the full radiation of the arc behind an aperture. An ammeter in series and a voltmeter across the lamp terminals gave the rate of consumption of electrical energy. A series of tints corresponding to the different exposures were obtained on the paper, and these were compared with standard tints

prepared on the same paper by steady exposures. The method was further developed so as to give a series of simultaneous records over the whole length of the arc. Finally, the phenomena were recorded by a Hilger quartz spectrograph on panchromatic plates. The radiation was found undoubtedly to have a starting maximum. The lines seen in the spectrum could be divided into three groups, *viz.* :—

1. Lines which show small but gradual increase of intensity as the lamp runs steady.

2. Lines which show an initial maximum followed by a drop and steady rise. The line $\lambda = 2536$ shows this particularly well marked.

3. Lines which do not appear at all until an interval after the arc is struck. The line $\lambda = 2848$ appears only in the starting spectrum for the first 30 secs., and cannot be subsequently detected.

To see if these phenomena were peculiar to the mercury arc other metallic arcs were tested similarly. The iron arc showed a starting maximum, but others were too unsteady to give reliable results. S. G. B.

2755. *Method of Production of Radiations Intermediate between Ultra-violet and X-Rays.* **G. Reboul** and **Bodin.** (Comptes Rendus, 179. pp. 37–39, July 7, 1924.)—In a series of earlier papers one of the authors has shown that a high-resistance conductor of heterogeneous composition, traversed by an electric current, is the source of emission of a very soft radiation, capable of ionizing a gas, of wave-length situated between ultra-violet and X-rays [see Abstracts 1149 (1921) and 2266 (1922)]. In these earlier experiments the source of radiation was simply formed by sheets of paper carrying current at a suitable voltage. The present experiments extend the investigation to a large variety of chemical conductors, pulverised and pressed into tablet form, these being chiefly compounds of mercury, copper, iron and tin. The results are given in tabular form, indicating the voltage necessary to produce the radiation and the intensity of the latter in arbitrary units. A study of the absorption coefficients in air of the soft radiation yields values varying between 9 and 15 cm^{-1}. A. B. W.

2756. *Quantitative Infra-red Absorption Measurements and Molecular Structure.* **J. Lecomte.** (Comptes Rendus, 178. pp. 2073–2075, June 16, 1924.)—Measurements of absorption on different organic substances have led to the following conclusions: Opacity is often a function of the organic groups contained in the molecule, *e.g.* OH ; $= C = C =$; must be examined in thicknesses of not more than $\frac{1}{100}$ mm.

The effect of groups is not additive ; if the same group enters twice into a molecule the absorption is not doubled. If two groups are close together in the molecule the two peaks are well defined ; the more distant they become as other groups intervene, the more burred is the intervening region in the spectrum, and finally they join. This also seems to hold for groups which differ, *e.g.* the carbonyl and carboxyl groups. These facts are taken to indicate that it is not the whole molecule which vibrates, but groups within the molecule. A. C. M.

2757. *The Red Displacements of the Fraunhofer Lines.* **W. H. Julius.** (Zeits. f. Physik, 27. 1. pp. 23–29, 1924.)—The contention of E. St. John [*ibid.* 21. 3. p. 159, 1924] that the edge-centre displacements are a consequence of differential dispersion is now found to be untenable. New considerations are advanced in the present paper explaining such

displacements as due to anomalous refraction. Should the latter view be correct, the red displacements in the centre spectrum must also be traced to anomalous refraction. Having regard to these facts, the author opines the existence of the Einstein gravitational displacement to be at least very doubtful. H. H. Ho.

2758. *The Compton Effect.* **M. de Broglie** and **A. Dauvillier.** (Comptes Rendus, 179. pp. 11–14, July 7, 1924.)—In earlier investigations, using the K-rays of tungsten and secondary radiators of carbon and aluminium, the authors have obtained photographic evidence confirmatory of the results published by A. H. Compton [see Abstract 1487 (1924)]. Clark and Duane, on the contrary, interpret the authors' remarks in another manner. It is now shown that the Compton effect can be obtained using radiators of silver, boron, glucinum and aluminium. The Compton effect is shown to be produced in these cases without any sign of the "tertiary radiation" of Clark and Duane. A. B. W.

2759. *Spectrographic Investigation of the Compton Effect.* **A. Dauvillier.** (Comptes Rendus, 178. pp. 2076–2078, June 16, 1924).—An investigation of the Compton effect is described, using an experimental arrangement which permits of variation of the wave-length of the primary X-rays and the azimuth and nature of the diffuser. As exciting rays the Kα-rays and silver and copper and the Lβ-rays of gold have been employed. As diffusers, lithium, carbon (graphite), aluminium, copper, silver, gold, lead. Of these diffusers lithium only has given entirely negative results—the cause of this is still undiscovered. The Compton effect is only shown well with Kα-rays of silver and a radiator of graphite.

Radiating a diffuser of graphite with different wave-lengths, it has been found that the Compton effect becomes very weak at 1·0 Å.U., and disappears completely about 1·5 Å.U. It does not exist, of course, in the region of optical wave-lengths.

The author concludes that the Compton effect only appears in the case where the selective absorption is very feeble, and it is far from having the generality predicted by the theory. A. B. W.

2760. *Magnetic and Electric Spectroscopy.* **W. Arkadiew.** (Zeits. f. Physik, 27. 1. pp. 37–55, 1924.)—The paper deals mathematically with a collection of the experimental results of a large number of investigators who have measured the magnetic permeability of wires of iron, nickel, etc., over a wide range of frequencies. Plotting permeability μ against frequency ν for a particular specimen, it is found that the magnetic spectrum is very complex, the permeability varying in a most irregular manner with frequency. The range of values plotted extends from $\lambda = 10$ $\mu\mu$ to 10^6 km. *i.e.* from ordinary optical wave-lengths to the longest wireless waves. Various theories are discussed in an attempt to analyse these experimental values. A. B. W.

2761. *Extension of a Property of Band Spectra to a number of Line Spectra.* **H. Deslandres.** (Comptes Rendus, 179. pp. 4–11, July 7, 1924.)—Previous work on band-spectra has shown that the frequencies of the strongest heads are multiples of the elementary frequency 1062·5, and a formula has been given [see Abstract 1203 (1919)] for the frequencies of the entire spectrum. It has now been recognised that a considerable number of *raies ultimes* expressed in frequencies are also multiples of

the same elementary frequency. Deviations from this approximate rule are shown for the most prominent lines of a number of elements. F. S.

2762. *Spectra and Critical Potentials of Fifth Group Elements.* **A. E. Ruark, F. L. Mohler, P. D. Foote** and **R. L. Chenault.** (Bureau of Standards, Sci. Papers No. 490. pp. 463–486, 1924.)—This paper discusses the arc spectra and critical potentials of arsenic, antimony, and bismuth, revised values of the critical potentials being given, while information on the spectrum of singly ionised nitrogen and the various spark spectra of bismuth is included. The resonance potentials of the neutral atoms are found to correspond to the mean excitation voltages of groups of spectra lines. Photographs of the thermionic discharge in bismuth were used to separate the excitation stages of the bismuth atom; groups of spark lines appear at 14 ± 1 and 25 ± 5 volts. The description is very complete of the experimental work undertaken and of the voluminous data obtained. The bismuth absorption spectrum was studied in detail, while classifications of lines of N^+, As, Sb, Bi, and Bi^+ were obtained. As, Sb, and Bi are found to have doublet spectra, and, to describe phenomena connected with the existence of very narrow doublet levels in Al^+, Bi, and other elements, it is proposed to introduce a new quantum number, termed the fine quantum number. The paper is replete with tables and illustrations. H. H. Ho.

2763. *The β-Ray Spectrum of Radium and its Meaning.* **O. Hahn** and **L. Meitner.** (Zeits. f. Physik, 26. 3. pp. 161–168, 1924.)—The radium was purified as far as possible from emanation and the other active disintegration products, and deposited on a platinum wire by electrolysis as radium carbonate. After washing, the wire was carefully heated to incandescence for a few minutes. It was found that at the commencement of an experiment this preparation contained only one thousandth part of the equilibrium quantity of the active deposit. Photographs of the β-ray spectrum were taken at definite intervals after preparation. The first exposure took five hours, at the end of which time about 5 per cent. of active deposit had been formed; the second, twenty hours later, was for three hours, to reduce fogging from the emanation produced, which, however, was kept down by means of liquid air; other exposures were made later, the periods of interval increasing to several days. In the first exposure five lines were photographed; two of these increased in intensity in the later exposures, and were accompanied by new lines. All of these are due to the active deposits; the other three are due to radium; their energies are $1{\cdot}40 \times 10^{-7}$, $2{\cdot}73 \times 10^{-7}$ and $2{\cdot}95 \times 10^{-7}$ ergs, and the difference between the energies of the first and the second and the second and the third correspond, in order of magnitude, to the difference between the energies of separation of an electron from the K and L levels and the difference for the L and M levels; the conclusion is that the three β-rays originate in the K, L and M levels. It is found, however, that within the limits of accuracy of the experiments it is not possible to decide whether the β-rays are to be considered as coming from the radium atom or from the radon atom formed from it. Calculating on the latter assumption, the mean value of the energy of the γ-radiation which separates the three β-rays is $2{\cdot}98 \times 10^{-7}$ ergs and the wave-length is $6{\cdot}6 \times 10^{-10}$ cm. This is clearly a nuclear radiation. H. N. A.

2764. *Band-Spectra of Oxide and Chloride of Silicon, and of Chlorides of Carbon, Boron, and Aluminium.* **W. Jevons.** (Roy. Soc., Proc. 106. pp. 174–194, Aug. 1, 1924.)—Observations were made with a glass constant-deviation instrument, a quartz spectroscope, and a grating of the discharge through silicon-chloride vapour, $AlCl_3$ vapour (auxiliary heating used), CCl_4, $TiCl_4$, BCl_3, and a mixture of $SiCl_4$ and oxygen.

The uncondensed discharge in $SiCl_4$ vapour gives a system of u-v. bands degraded towards the u-v., in two parts on either side of $\lambda 2610$; each part is again divisible into sub-systems having wave-number separations of 525, 205, and 195. These bands are attributed to a chloride of silicon.

When oxygen is present in addition, another set of bands occurs, with heads degraded towards the red. These bands were previously observed by de Gramont and de Watteville, and attributed by them to silicon. Evidence is given for attributing them rather to an oxide of silicon. The heads have been remeasured and grouped.

The discharge in $AlCl_3$ gives band heads about 2610, which exhibit numerical relationships.

The bands given by CCl_4 and BCl_3 have also been measured; admission of oxygen in these cases also brought out the oxide band-spectrum.

The bands recently attributed by Mulliken to boron monoxide were not found when the oxide bands in the BCl_3 tube were developed, so that it appears that the earlier ascriptions to boron nitride probably still stands. A. C. M.

2765. *Distribution of Energy in the Mercury-Arc Spectrum.* **G. Athanasiu.** (Comptes Rendus, 178. pp. 2071–2073, June 16, 1924.)—Energy distribution in the mercury-arc has been measured, using a thermoelectric arrangement. The object was to find if the energy of the lines belonging to the same series underwent the same variations in intensity when the arc conditions were varied. The lines examined were the first triplet of the sharp series and the first two triplets of the diffuse series, and also the yellow group $\lambda 5769$–90.

It was decided that as the voltage varied (from 30 to 80 volts) the energy curves for lines belonging to the same series had the same character.

The intensity-ratio for two lines of the same series remained constant during the voltage interval examined. For lines belonging to different series the ratio varied greatly, and was even in some cases inverted. **Erratum** (*ibid.* p. 2288, June 30, 1924). A. C. M.

2766. *Mercury Band-Spectrum.* **K. T. Compton** and **L. A. Turner.** (Phil. Mag. 48. pp. 360–363, Aug., 1924.)—Observations on a hot-kathode tube containing mercury and hydrogen suggest that the well-known band-spectrum of mercury seen when mercury is distilled is due to a hydride of mercury, in agreement with the conclusions of Hulthén, Kratzer, and Mulliken. These have shown independently that the spectrum is probably due to a combination of a mercury atom with a light atom.

The band-spectrum almost entirely disappeared when the hydrogen was pumped out with a diffusion pump. The behaviour of the striations in the tube when the concentration of hydrogen was varied suggest that the spectrum is due to a reaction in which a mercury atom which has been excited combines with one hydrogen atom from a molecule, thus

liberating the other hydrogen atom. This hypothesis will also account for some observations of Cario and Franck. The bands appear with greatest intensity in the region where the concentration of excited mercury atoms in the $2p$ states is greatest. An attempt to excite these bands optically by absorption of $\lambda 2536$ resonance radiation in a mercury-hydrogen mixture failed. A. C. M.

2767. *A Possible Explanation of the Behaviour of the Hydrogen Lines in Giant Stars.* **K. T. Compton** and **H. N. Russell.** (Nature, 114. pp. 86–87, July 19, 1924.)—While the general behaviour of the absorption lines in stellar spectra has been well accounted for by thermodynamic theory, the Balmer series shows marked peculiarities. According to elementary theory, the fraction of all the hydrogen atoms present which are in the two-quantum state should be $f_2 = q_2 e^{-(x_1 - x_2)/KT}$, where $x_1 - x_2$ = resonance potential and q_2 the weight of the two-quantum state. For $T = 5000°$. $f_2 = 6 \times 10^{-11} q_2$.

For comparison take $\lambda 4481$ of Mg, for which at $T = 5000°$. $f_2 = 1{\cdot}2 \times 10^{-9} q_2$.

Yet the line $\lambda 4481$ is barely visible in the solar spectrum, and H_α is one of the strongest lines. It appears necessary, therefore, to assume that the effective value of q_2 for the two-quantum state of hydrogen is increased by a very large factor, which increases as the pressure diminishes. A tentative explanation may be found in the fact that one of the two two-quantum states of hydrogen is metastable. If it may be assumed that the number of hydrogen atoms in the $2s$ state in a star's atmosphere, and hence the effective value of q_2 is greatly increased when the life of the metastable state is long, the peculiar behaviour of the Balmer lines becomes explicable. Similar considerations are applied to the helium atom, and an observational test of this great concentration of atoms in metastable states, in stellar atmospheres not in equilibrium, is suggested. W. V. M.

2768. *Band-Spectrum of Hydrogen.* **H. S. Allen.** (Roy. Soc., Proc. 106. pp. 69–82, July 1, 1924.)—A review of the attempts made to classify the secondary hydrogen spectrum lines into band systems, together with a recalculation of the constants for the first and second Fulcher bands. It is shown that the lines of the series S_1 to S_7 in the first band are all due to the same molecular system; the constants obtained in the parabolic formulæ depend on the numeration employed, and so it is impossible from them to arrive at a definite value for the moment of inertia for the hydrogen molecule.

If the series S_1, S_2, S_3 are treated as half-quantum series, the values $1{\cdot}761 \times 10^{-41}$ and $1{\cdot}827 \times 10^{-41}$ gm./cm.^{2} are obtained for all the series for the initial and final states of the molecule. The constants in the formulæ for the second band correspond to smaller values of the moment of inertia, and therefore contradict the suggestion of Kiuti that the first and second bands and his high-pressure series are all due to the same molecular system. Certain new series are recorded. A. C. M.

2769. *Ultra-violet Oxygen Emission Bands.* **R. C. Johnson.** (Roy. Soc., Proc. 105. pp. 683–691, June 2, 1924.)—A redetermination of the wave-lengths of the ultra-violet emission bands was made, using an end-on tube, carefully cleaned and purified oxygen being obtained by having

side-tubes containing caustic potash (carbon-removal as dioxide), phosphorus pentoxide (removal of water-vapour), and $K_2Mn_2O_8$ (provision of oxygen by heating). Six-hour exposures were made, fresh oxygen being admitted every twenty minutes.

The identity of the bands with ozone emissive bands is held to be now excluded, differing with Staube and others. Faint bands were recorded at the time, which probably were due to ozone. The main oxygen band system can be represented by

$$\nu = \begin{Bmatrix} 1620 \\ 1420 \end{Bmatrix} + 16 \cdot 945\, p^2 - 13 \cdot 37 m^2.$$

This is similar to the arrangement of the first positive nitrogen bands and the longer wave-length cyanogen bands. The fine-structure is not sufficiently clear to calculate what oxygen molecule is responsible for this band-spectrum. **A. C. M.**

2770. *The Absorption Spectra of the Elements of the Iron Group.* **E. v. Angerer** and **G. Joos.** (Ann. d. Physik, 74. 8. pp. 743–756, Aug., 1924.)—The importance of absorption spectra in the investigation of atomic structures is first discussed by the authors. The effect of temperature on the numbers of atoms out of their "normal" state is mentioned, and a table drawn up showing that if the energy difference between normal and excited state be great enough, the effect is negligible. Experimental details of the source of light (an aluminium spark) and of the production of the metallic vapours are given, together with a description of the spectrograph used. A table of wave-lengths of observed absorption lines of the iron spectrum is included, classification being made according to the triplet-quintet system of previous workers. It is concluded that the "fundamental level" (Grundzustand) is the d' level. This is unlike the results for any other atom, and implies that the magneton number is 6. Tables are also given of absorption lines for Co and Ni, but so far no general scheme has been found for these spectra. Experiments have also been performed on iodine, and it is concluded that atomic iodine is "transparent" between 6700–2300 Å. **W. V. M.**

2771. *On the Luminescence of Nitrogen, Argon and other Condensed Gases at very Low Temperatures.* **J. C. McLennan** and **G. M. Shrum.** (Roy. Soc., Proc. 106. pp. 138–149, Aug. 1, 1924.)—The paper contains the results of experiments made by the authors on the bombardment by electrons of N, Ar, CO, O_2, NH_3, and water-vapour. The conclusions of Vegard [see Abstract 2093 (1924)] are not confirmed, the main results being :—

1. When nitrogen vapour at − 252° C. was irradiated by electrons of high and low speeds, it became luminescent, and the spectrum of the emitted light was found to include three wave-lengths in the yellow-green region at $\lambda = 5556$, 5617, and 5654 Å.

2. When argon was similarly treated the spectrum of the light emitted included two wave-lengths in the yellow-green region at $\lambda = 5648 \cdot 3$ Å. and $\lambda = 5607 \cdot 4$ Å.

3. The spectrum of nitrogen phosphorescing at the temperature of liquid hydrogen was found to consist in the visible region of a single wave-length at $\lambda = 5231$ Å. Irradiation by electrons caused solid nitrogen to phosphoresce brilliantly.

4. The spectrum of argon phosphorescing at the same low temperature consisted in the visible region of a strong wave-length at $\lambda = 4750$ and a weak one at $\lambda = 5300$ Å.

5. The phosphorescence of N at low temperatures was very brilliant, and persisted for some minutes after excitation ceased, while that of argon died out rapidly and was visible for a few seconds only after excitation was stopped.

6. Solid carbon monoxide (chosen for experimental test because of its electronic configuration being similar to that of nitrogen), ammonia, oxygen and water-vapour did not phosphoresce and did not become luminescent under irradiation by electrons at the temperature of liquid hydrogen.

7. From the fact that the excited luminescence lines in the spectra of very cold nitrogen and argon do not coincide even in part with the green auroral line $\lambda = 5577$ Å., the authors are forced to the conclusion that the origin of the auroral green line cannot as yet be definitely connected with the elements nitrogen or argon.

8. The experiments, as carried out so far, do not preclude the possibility of the auroral green line having its origin in some lighter element—in solid hydrogen, or in very cold luminous hydrogen, or helium or hydrogen-helium vapours, for example—provided the proper mode of excitation be used. W. V. M.

2772. *Fine-Structure of Nitrogen, Oxygen, and Fluorine Lines in the Extreme Ultra-violet.* **I. S. Bowen** and **R. A. Millikan.** (Phil. Mag. 48. pp. 259–264, Aug., 1924.)—A report has already been made of the rough wave-lengths of lines in this region, using first-order spectra [Abstract 1466 (1924)]. Fine-structure work has now been done in orders up to the tenth. The same hot-spark method has been employed, and the separations are claimed to be accurate to about 0·01 Å. Thus wave-length standards in the region below 1000 Å. are now provided. It is shown that λ834·0 O and λ1085·2 N are not due to the stripped atoms, as was at first supposed, while 1550 C and not 1335 C is due to the stripped carbon atom. The main purpose of the paper is to draw attention to the accuracy now being obtained in this region. Complete details are to appear later. A. C. M.

2773. *Structure of the Second Positive Group of Nitrogen. Part I.* **P. Lindau.** (Zeits. f. Physik, 25. 3. pp. 247–252, 1924.)—This part describes a projection apparatus designed to facilitate the measuring up of the author's spectrograms, owing to the great complexity of this spectrum. Between 3450 and 3900 there are five lines per Å.U. The calibration and accuracy of the apparatus are discussed. A. C. M.

2774. *Absorption-Spectrum of Naphthalene-Vapour and Structure of the Naphthalene-Molecule.* **V. Henri** and **H. de László.** (Roy. Soc., Proc. 105. pp. 662–682, June 2, 1924.)—A concise account of the quantum theory of band-spectra is given, followed by detailed illustration in the case of naphthalene vapour. Proceeding in the direction of finer resolution, band-groups are due to change of electronic configuration, narrow bands to change of atomic arrangement (in many cases, *e.g.* the present, groups of atoms rather than single atoms), and the band-lines to molecular rotation. It is found that often narrow bands exist without possessing

fine-structure, *i.e.* atomic vibration without molecular rotation being quantised. In many substances the band-lines disappear from the bands beyond a certain wave-length going into the ultra-violet, and at a still further limit the narrow bands also vanish.

A tentative explanation is put forward as follows: A molecule consisting of atomic groups A.B. are bound together by electrons having common orbits around A and B or in symmetrical positions. Quantisation of the mutual vibratory movements gives rise to narrow bands and lines. For low frequencies, transitions are involved leading to little change in the electronic positions; but as the frequencies become greater the bands may become looser, and so the rotatory movement of the molecule ceases to be quantified, so that the fine structure of the bands vanishes. This leads to a determination spectroscopically of the energy required to bring about this intramolecular change, *e.g.* in naphthalene 101,000 cals. per gm./mol. The present measurements were made with quartz spectrographs upon a tube entirely of quartz, using as a source of continuous light the condensed discharge under water, with either Cu or Al electrodes. Intensities were measured by finding the minimum pressure of the vapour at which the band was first visible; the intensity of the band is then given by the inverse of the pressure. The wave-lengths of the bands are considered in detail, and fitted into the quantum formulæ. The spectrum is much less complicated than would be expected from the great molecular weight; it appears to be due to the vibrations of the two benzene nuclei and the two C_3H_3 groups in each nucleus. The moment of inertia of the molecule is calculated from the fine-structure formulæ, and would appear to be smaller than the value which follows from Bragg's dimensions (which assumes the distance between the carbon atoms to be the same as in the diamond crystal). A. C. M.

2775. *The Origin of the So-called Cyanogen Band, 3883 Å.* **E. Freundlich** and **E. Hocheim.** (Zeits. f. Physik, 26. 2. pp. 102–105, 1924.)—Spectrographic records were made of a specially designed spectroscopic oven, firstly, of nitrogen in the presence of carbon, and, secondly, of nitrogen in the absence of carbon. In both cases the oven was heated sufficiently (to about 2150°) to produce the emission of the 3883 Å. band. The oven itself consisted of a tungsten tube supported horizontally between two electrodes and enclosed in a steel bomb. The bomb had quartz windows at either end, so that vision was possible through the tube in the direction of its length. The temperature was observed by a Kurlbaum pyrometer. A quartz lens was utilised to focus the light on the slit of a spectrograph. The latter had a Rowland grating and a Littrow mounting for slit and camera. The dispersion was about 2 Å. per mm. It was found that the band 3883 Å. does not appear if carbon is absent, but only occurs when carbon is present. S. G. B.

2776. *Luminescence of Solidified Gases.* **L. Vegard.** (Comptes Rendus, 179. pp. 151–153, July 21, 1924.)—Neither argon nor any of the gas examined give under canal-rays or rapid kathode-rays a luminescence comparable to that of solid nitrogen below 35·5° K, which is the only gas applicable to the aurora borealis. A. D.

2777. *Emission Spectra of Mixed Alkali Vapours.* **F. H. Newman.** (Phil. Mag. 48. pp. 159–163, July, 1924.)—A continuation of earlier work

[see Abstract 63 (1924)]. Sodium-potassium alloy formed the electrode in a quartz tube, having side-tubes at the electrodes. Spectra were photographed at different pressures; at high vapour pressures auxiliary heating was provided by a nichrome coil wound round the tube, but otherwise the heating effect of the discharge was sufficient to maintain sufficient vapour. The sodium-potassium bands increased in brightness as the current increased or the temperature of the tube increased. A table is given of the wave-length of the band-lines. A. C. M.

2778. *Luminous Spectra of Solid Nitrogen.* **L. Vegard.** (Comptes Rendus, 179. pp. 35–37, July 7, 1924.)—Examination of the spectrum of solid nitrogen bombarded by kathode-rays of small velocity with high dispersion shows a band, N_1, giving a principal maximum at $\lambda = 5555$ Å., with secondary maxima at 5611 and 5649, and a second band, N_2, appearing as a single diffuse line at $\lambda = 5229{\cdot}4$ Å. A layer of solid argon containing traces of nitrogen gives a narrower N_1 with a principal maximum at 5604. Thus for different concentrations of nitrogen the principal maximum varies over a range containing the line of the aurora borealis at its centre. The narrowing of the bands, which is independent of the temperature, thus occurs when the particles of nitrogen become smaller. The line of the aurora ($\lambda = 5577$ Å.) is the limit of N_1 when the crystals of nitrogen in space are reduced to molecular dimensions. Nitrogen so bombarded also gives both in the ultra-violet and in the red characteristic bands which are found in the spectrum of the aurora, but a different effect is obtained when the bombarding is by positive rays of nitrogen, helium, and hydrogen. Here the bands correspond to those observed by Rayleigh in the light of the night sky. G. A. S.

2779. *The Tungsten M-Series.* **R. Thoraeus.** (Zeits. f. Physik, 26. 6. pp. 396–399, 1924.)—The paper is a continuation of the work of the author on X-ray spectroscopy and records many new measurements of the M-series for tungsten. This was rendered possible mainly by the substitution of a thin celluloid membrane coloured red, as window of the X-ray tube, in place of the previously used gold-leaf covering. A table of results is given, and shows that of the 17 anticipated spectrum lines of the M-series of tungsten all but four were found and actually measured. The paper contains full experimental details and notes of procedure.
S. G. B.

2780. *A Note on the Excitation of the so-called Spark Lines in the K-Series of the Röntgen Spectra and the Theory of Wentzel.* **E. Bäcklin.** (Zeits. f. Physik, 27. 1. pp. 30–31, 1924.)—The lines α_3, α_4, α_5, α_6 of the K-series appear to be a multi-ionisation of the atom as assumed on the Wentzel theory [see Abstract 1313 (1922)]. The present investigation seeks to obtain a more exact connection between the lines and the different ionisation degrees possible. The $K\alpha_4$ and $K\alpha_6$ lines of aluminium have been photographed with the Siegbahn vacuum spectrograph at voltages less than the excitation ones employed by Wentzel, and from the data obtained it would appear that the present form of the Wentzel theory is not entirely in agreement with the facts. H. H. Ho.

2781. *X-Ray Spectroscopy. The Cause of the Swelling in Various Fibres.* **J. R. Katz.** (Phys. Zeits. 25. pp. 321–326, July 1, 1924.)—The

question whether water is taken up between "mizellen" (small crystals or other small bodies of 1 to 100 $\mu\mu$ magnitude), *i.e.* intermizellar, or as solid solutions, *i.e.* intermolecular, can be subjected to direct experimental proof by X-ray spectroscopy. The general experimental arrangement is described in detail and the following points are considered: the swelling of cellulose and cellulose-hydrate in water, the swelling of silk-fibroin in water. The fibres used are unmercerised Ramie, Ramie which has been slightly mercerised, manilla hemp, artificial silk of the viscose variety, artificial silk of the cuprammonia type, Ramie which has been very strongly mercerised in zinc-chloride solution, and silk of the Bombyx mori. Photographs are given which show the influence of the swelling on the X-ray spectrogram in the case of cellulose hydrate in fibre form, silk-fibroin and Ramie. It is concluded that it is probable that with cellulose, cellulose-hydrate and silk-fibroin the swelling is intermizellar. It is, however, stated thas these experiments must not be taken to indicate that the swelling is always intermizellar, but each case must be considered on its individual merit. A. E. G.

2782. *Liquid Crystals, Soap Solutions and X-Rays.* **J. W. McBain.** (Nature, 114. p. 49, July 12, 1924.)—A photograph is shown of the transparent anisotropic plastic phase occurring in 2·5 N solution of potassium laurate at 45°, use being made of slightly convergent light and crossed Nicols. The characteristic fan-like structure composed of focal lines is shown very clearly, ample justification being furnished for Friedel's designation of this state of matter as "liquide à conique," which he now proposes to supersede by the term "smegmatic" (smectique), in order to place soap-curds in this class. Since, however, curd-fibres are discrete and differ greatly in almost every way from the conic anisotropic liquid soap examined by the author, the classification of opaque soap-curds as smegmatic appears inapt. T. H. P.

2783. *Scattering of X-Rays by Free Electrons.* **K. Försterling.** (Phys. Zeits. 25. pp. 313–320, July 1, 1924.)—After referring to the work of Compton [Abstracts 2194 (1923) and 1489 (1924)] and of Debye [Abstract 1878 (1923)], the author deals mathematically with the scattering of X-rays by free electrons. In the first section of the paper the transformations of energy during the passage of homogeneous light waves through free electrons are dealt with according to Maxwell's theory. This is followed by a treatment of the subject on the basis of the quantum theory. A comprehensive abstract is not possible; the original should be consulted. A. B. W.

2784. *Scattered X-Rays.* **P. A. Ross.** (Nat. Acad. Sci., Proc. 10. pp. 304–306, July, 1924.)—The writer has previously published a photograph of the molybdenum K-lines scattered at 90 from a paraffin block. This spectrogram showed an unshifted scattered line and a shifted line agreeing in position with that required by Compton's quantum theory of scattering. It has since been suggested that the shifted line might be explained by the tertiary radiation theory of Clark and Duane. More recent and much better spectrograms make it clear that this explanation is not tenable. From the spectrograms here published it may be seen that there is a shift of the magnitude required by the Compton theory not only when the radiation is scattered by light elements, but also an

exactly equal shift with a heavy element, such as lead. It can be seen that toward the heavy elements the intensity of the shifted as compared with the unshifted line falls off very greatly. Two of the spectrograms show the variation of the intensity and amount of shift with angle of scattering. The amount of shift at 30° and 60° agrees with that required by theory. That this line cannot be due to a strongly filtered tertiary peak from carbon and the shift and decrease of intensity due to greater filtering at small angles is proved by the fact that at 30° the modified line has moved past the short wave-length limit of the tertiary peak computed from the carbon K-absorption limit. A. E. G.

2785. *The Scattering of X-Rays.* **A. H. Compton.** (Frank. Inst. J. 198. pp. 57–72, July, 1924. Based on paper read before the Am. Assoc. for Adv. of Science, Dec., 1923.)—This paper is confined to a discussion of some of the points which present a revolutionary change in ideas regarding the process of scattering electromagnetic waves. No attempt is made to describe the great amount of experimental and theoretical work which has been done on the subject. The theoretical researches of J. J. Thomson and the experimental work of Barkla and others had shown so striking an agreement between experiment and the theory of the scattering of X-rays based upon the usual electrodynamics that scattering has been classed with dispersion and interference as a phenomenon that is completely explicable according to classical ideas. Within the past two years, however, scattering phenomena have been observed which are so directly contrary to the production of the usual electrodynamics that the attitude taken has apparently almost to be reversed completely. It was thought that the scattering of X-rays could be explained on the assumption that radiation proceeds in spherical waves, spreading in all directions in space. It is now found that to retain this assumption, if recent results are correct, both the principle of the conservation of energy and the principle of the conservation of momentum must be abandoned. On the other hand, the observations can be explained simply by imagining the rays to consist of discrete quanta proceeding in definite directions. A diagram of the apparatus used is given. A photograph shows the spectrum K-rays from molybdenum scattered from paraffin and reflected from calcite. It is endeavoured to show that the existence of recoil electrons and the close agreement with the predictions as to their number, direction and velocity supplies strong evidence in favour of the fundamental hypotheses of the quantum theory of scattering. [See also Abstracts 534, 551, and 1186 (1924).] A. E. G.

2786. *X-Ray Phosphorescence.* **J. A. Bearden.** (Nature, 113. pp. 857–858, June 14, 1924.)—In examining photographs of the β-ray tracks produced in air, C. T. R. Wilson [Abstract 2213 (1923)] found that two tracks, which were undoubtedly pairs, were not alike: one was sharp and the other was a diffuse track—that is, pairs exist of which the two components have been ejected with an appreciable time interval. He roughly estimates this time interval to be of the order 0·001 of a second. The first track he attributed to the photoelectron ejected by the primary X-ray, and the second track to an effect of the resulting fluorescent radiation.

The author now outlines an investigation of this secondary radiation by a more direct method. It is shown that the time interval between

the incident X-rays and the fluorescent rays excited in iron and aluminium must be less than 10^{-5} seconds. In these experiments the elements used were of higher atomic number than were those used by C. T. R. Wilson, and they were also solids instead of gases. The results obtained are thus not necessarily inconsistent with Wilson's conclusion that in his experiment a time interval of 10^{-3} seconds elapses between the receipt of the primary ray and the emission of the fluorescent ray. A. B. W.

2787. *X-Ray Diffraction Images of Slits.* **B. Walter.** (Am. d. Physik, 74. 7. pp. 661–672, July, 1924.)—Using wedge-shaped slits of the order of 40 μ in width the author has obtained diffraction images on a photographic plate when the slit is illuminated by monochromatic X-rays from a copper anti-kathode. The observed positions of the first and second diffraction lines are in approximate agreement with the values calculated from the dimensions of the apparatus and wave-length of the X-rays. The important bearing of the observations on X-ray spectrographs is discussed. A. B. W.

2788. *X-Ray Spectrographic Observations with Cellulose. III.* **H. W. Gonell.** (Zeits. f. Physik, 25. 2. pp. 118–120, 1924.)—Reference is made to previous investigations on the structure of cellulose by X-ray methods [see Abstract 1084 (1921)]. The present note deals with the structure of "broom," "mulberry" and hydrocellulose, X-ray photographs showing the Debye-Scherrer interference rings, indicating the crystalline structure, being reproduced in each case. A. B. W.

2789. *Anomalous Zeeman Effects.* **W. Heisenberg.** (Zeits. f. Physik, 26. 4–5. pp. 291–307, 1924.)—Endeavours, by a simple extension of the quantum-theory rules, to describe a part of the phenomena due to the coupling of several electrons and to set forth the laws of multiplets and the Zeeman effect in a more coherent form. The departures from the law of superposition and the permanence law of the Zeeman effect seem hardly explicable unless we admit that one value of the coupling energy is to be defined, not by one number of quanta, but by two. A. D.

2790. *X-Ray Studies of Copper-Aluminum Alloys.* **E. R. Jette, G. Phragmén** and **A. F. Westgren.** (Inst. of Metals, J. 31. 1. pp. 193–206; Disc. and Corres., 206–215, 1924.)—A number of alloys of aluminium with copper have been submitted to X-ray analysis, and it is concluded:—

1. In the α-phase simple substitution of aluminium atoms for copper atoms takes place, resulting in an enlargement of the lattice.

2. Addition of copper to aluminium causes a slight shrinkage of the lattice.

3. The γ'-phase (16–25 % Al) is formed by complex substitution, probably three copper atoms being replaced by two aluminium ones.

4. The δ-phase ($CuAl_2$) is a body-centred tetragon, axial ratio 1 : 0·805.

5. Attempts were made to determine the structure of the β-phase, but without much success.

In the *Discussion*, **H. Weiss** pointed out that the difference between the authors' structure for $CuAl_2$ and that of Owen and Preston was not so great as might appear at first sight. He also discussed the relative advantages and disadvantages of the powder method of X-ray analysis.

E. A. Owen discussed the structure of an alloy containing 27 % Al, which might be interpreted either as a symmetrical solid solution or as a chemical compound. **W. Rosenhain** emphasised the need of careful metallurgical manipulation as well as of accurate physical measurements. He suggested that the complex substitution in the γ'-phase might be explained by assuming non-homogeneity. He also discussed the difference between solid solutions and compounds. **F. C. Thompson** uttered a warning against the use of the powder method with ductile materials. J. L. H.

2791. *The Chance of an Electron being Ejected Photo-electrically from an Atom by X-Rays.* **G. E. M. Jauncey.** (Phil. Mag. 48. pp. 81–88, July, 1924.)—Suggests that Owen's law should be replaced by an empirical law that the chance of an electron being ejected photo-electrically from an atom by X-rays is proportional to the cube of the wave-length of the X-rays and to the square of the binding energy of the electron to the atom, provided that the wave-length is short enough to eject the electron. Experimental data. A. D.

2792. *Spectrophotometry of the Zeeman Effect in very Weak Magnetic Fields.* **W. Mohammad.** (Phil. Mag. 48. pp. 586–592, Sept., 1924.)—Spectrophotometric observations of the Zeeman effect exhibited by the zinc red line λ6364 Å. in weak magnetic fields ranging from 290 to 871 Gauss confirm Voigt's conclusion that in weak magnetic fields the resolved lines exhibit a dissymmetry such that the greater intensity is exhibited by the outer component on the red side, whilst the component on the violet side is more displaced from the normal position of the unresolved line. Such dissymmetry may be attributable to coupling between electrons having different frequencies, to a modification of the quasi-elastic forces, to a change in the structure of the radiating particles due to the magnetic field, or to interaction of the magnetic and electric forces. [See also Abstract 1252 (1914).] J. S. G. T.

RADIO-ACTIVITY.

2793. *Quantum Theory of Radioactive Transformations.* **A. Smekal.** (Zeits. f. Physik, 25. 4–6. pp. 265–278, 1924.)—The author applies his quantum theory of radio-active transformations, first proposed in 1922, to the results of Ellis and Skinner [Abstract 1207 (1924)] and of Meitner [Abstracts 1639 (1922) and 2451 (1923)] on the relation of the β-ray spectrum lines to the γ-radiations from radium decay products. A. B. W.

2794. *The Precipitation of Polonium by Silver Chloride.* **J. Escher-Desrivières.** (Comptes Rendus, 179. pp. 158–160, July 21, 1924.)—Pure polonium is deposited on a silver plate, and dissolved in HNO_3; the silver is precipitated with HCl, and the polonium is, in general, left in the acid solution, and not carried down with the AgCl precipitate. If, however, there is only a feeble excess of HCl a large proportion of the polonium is carried down with the precipitate; but as the amount of HCl increases the amount of polonium left in the liquid increases; if the liquid contains a definite amount of HCl the addition of NaCl, NaCl, LiCl or ferric chloride will increase the amount of polonium "stabilised" in the liquid; bivalent chlorides (Ba, Zn, Mg) are inactive. The ratio of the dissolved to the precipitated polonium X is equal to $ac^{\alpha(M_1n_1+M_2n_2)}$;

where a and α are constants, the former depending on the mass of the precipitate, n_1 is the number of molecules of HCl in the volume considered, n_2 the same for the alkaline, chloride, and M_1 and M_2 are the molecular masses of the acid and of the chloride. H. N. A.

2795. *The Radio-activity of Certain Thermal Springs in Madagascar and Reunion.* **C. Moureu, A. Lepape** and **H. Moureu.** (Comptes Rendus, 179. pp. 123–129, July 21, 1924.)—None of the twenty-one springs examined showed strong radio-activity, though some radon and radium was found in all of them; a number of them were in a volcanic region, the basin of Antsirabe in Madagascar. It is thought that the low radio-activity is due to the fact that volcanic rocks, as a rule, are not very radio-active; though in certain places veins of pegmatite which were particularly rich in uranium minerals were found; these did not greatly affect the springs in the immediate neighbourhood; but seem to have raised the radio-activity of all the springs in the basin, which was somewhat higher than that for most of the springs in the Central French plateau. H. N. A.

2796. *The Action of γ-Rays in Atomic Disintegration.* **L. Meitner.** (Zeits. f. Physik, 26. 3. pp. 169–177, 1924).—It has been found by the author, in collaboration with O. Hahn, in an investigation the results of which have not as yet been published, that radio-actinium and actinium X, when they disintegrate giving out α-particles, produce typical monochromatic γ-radiations, as radium is shown to do in Abstract 2763 (1924). With these two substances a large number of monochromatic nuclear γ-rays have been shown to be produced, instead of a single one as in radium. When an α- or β-particle is given out from the nucleus of a radio-active atom the remainder of the nucleus must undergo a rearrangement of its constituent parts; two processes seem to be possible, first an alteration of the nuclear configuration without radiation, and second a quantum change with emission of a monochromatic γ-ray; the first is seen in the α-radiators Io, Po, ThC′ and the β-radiators UX_1, RaE, and ThC; with larger disturbances γ-rays are emitted, and the number of different kinds, and their energy (frequency) will increase with the magnitude of the disturbance. This view point is shown to differ from that previously taken by the author, and also from that recently upheld by Ellis and Skinner, who deduce the stationary states of the RaB nucleus directly from the γ-rays emitted. A consequence of the new assumption is that, in calculating the energy of the β-rays the energy levels of the resulting atom, and not those of the original atom, must be considered; when the γ-rays have large energy it seems that even the great accuracy obtained in the measurements of Ellis is not sufficient to lead to a decision; but with γ-rays of longer wave-length this appears to be possible. Ellis has found, in the case of his slowest C-group of β rays from RaB, that they seem in fact to be emitted from RaC, the atom resulting from the disintegration. The author thinks that the explanation that all the β-rays are produced in this way is simpler than that given by Ellis, while it agrees equally well with the experimental results. It is shown that the experiments in which Ellis and Skinner allow the γ-rays of RaB to fall on platinum, and examine the β-rays produced in a magnet field, confirm this view numerically. H. N. A.

HEAT.

2797. *Double Mirror Dilatometer for Low-Temperature Work.* **G. Borelius** and **C. H. Johansson.** (Ann. d. Physik, 75. 1. pp. 23–36, Aug., 1924.)—A brass plate resting on two supports has a pair of parallel mirrors fixed one at either end. The specimen under test is fastened rigidly at its upper end whilst its lower end is attached to the centre of the brass plate. As the specimen expands or contracts, this plate is bent and the amount of bending is determined in the usual way using a beam of light reflected from the mirrors in turn. The variation of angle between the mirrors depends only on their distance apart and the amount of bending of the plate. The whole apparatus is enclosed in a chamber and the temperature is varied by the use of liquid air and measured by a platinum thermometer. The range is down to about — 200° C. Some results are given for specially pure copper rods and also for crystals of zinc and cadmium in various directions relative to the axes. A. A. D.

2798. *A Recording Apparatus for the Measurement of the Expansion of Glass.* **A. Arnulf.** (Rev. d'Optique, 3. pp. 270–276, June, 1924.)—The paper gives details of an apparatus for obtaining a continuous record of the expansion of samples of glass of thin dimensions. An interference method is employed, derived from that of Fizeau, and as the expansion is measured directly, the need for a standard body for purposes of comparison is dispensed with. The displacements of Newton's rings—formed between two surfaces, one spherical and the other plane, separated by an annular wedge of the specimen under examination—are registered and then counted. The registration of the displacements of the rings is accomplished by projecting them on to a slit, placed initially over their centre, and across which a photographic plate is drawn in a direction perpendicular to the length of the slit. Initially, the record on the plate consists of parallel lines, but as the temperature is raised the rings are displaced, the lines become curved, and eventually meet at the point of disappearance. These points are well marked on the record and by determining the number of such points for a given rise of temperature, the exact expansion can be determined. The apparatus is enclosed in a box around which a heating coil is wound. By passing a current through this coil temperatures up to 300° C. are obtained. A mercury lamp furnishes the source of monochromatic light. The paper concludes with a detailed description of the apparatus, and directions, precautions, etc., for its use. A sample can be completely examined in half an hour. S. G. B.

2799. *Apparatus for Measuring the Heat Produced by Radio-active Substances.* **D. Yovanovitch.** (Comptes Rendus, 179. pp. 163–165, July 21, 1924.)—Two identical Dewar flasks are placed in cylindrical cavities in a block of iron, and the cavities are filled with mercury and covered up. The iron block is protected from outside influences by three concentric lead boxes, with cotton in the interspaces. The substance to be examined is placed in one of the flasks, and in the other is a coil which can be heated by an electric current; this is adjusted until the temperature in the two flasks remains permanently equal, as shown by a thermopile the alternate junction of which are in opposite flasks. The

measurements are repeated, using a standard radium preparation, taking into account the formation of polonium. H. N. A.

2800. *Temperature Measurements by Means of Thermoelectric Junctions.* **J. Würschmidt.** (Zeits. f. Metallkunde, 16. pp. 271–274, July, 1924.)—The usual statements regarding thermoelectric forces between different metals can only be used with caution, partially on account of imperfect precision in definition and partially because of the uncertainty of the results of measurement. The paper seeks to give clear conceptions and definitions of the meaning of the expressions "Thermoelectric force for a given temperature interval," "Actual thermoelectric force per degree," and "Mean thermoelectric force per degree for a known temperature interval." The theoretical significance of these statements is fully treated and the formulæ thus derived are utilised for securing tables of absolute values of thermoelectric forces. The thermoelectric forces are always expressed in microvolts as being more useful than millivolts. Tables are given showing thermoelectric forces between 0° and 100° for both mean and actual values per degree, and tolerable agreement is found between the theoretical and observed results. If the thermoelectric forces of three different bodies in relation to a single normal body (*e.g.* bismuth) under exactly similar conditions are known and designated by E_1, E_2, and E_3.

Then $$E_{32} = E_3 - E_2 \qquad E_{21} = E_2 - E_1$$
$$E_{31} = E_3 - E_1$$

and hence $$E_{32} + E_{21} = E_{31}.$$

This relation is shown to be approximately in agreement with experimental observation and a series of values due to Becquerel [Ann. Chim. Phys. vol. 41. p. 353, 1829] are used for this purpose. The results are shown in tabular form. The paper concludes with a table showing a series of thermoelectric potentials for important metals and alloys in relation to bismuth, which can be utilised for the measurement of high temperatures. S. G. B.

2801. *Irregularities in the Specific Heats of Certain Organic Liquids.* **J. W. Williams** and **F. Daniels.** (Am. Chem. Soc., J. 46. pp. 1569–1577, July, 1924.)—The specific heats of most liquids increase regularly with the temperature either as straight-line functions or as curves which become steeper as the temperature rises. The authors have examined fifteen organic liquids by means of their adiabatic calorimeter and have measured their specific heats at temperature intervals of 2°. They find that benzene, ethyl benzene, and carbon tetrachloride exhibit distinct irregularities, indicating molecular changes in the liquid. Nitrobenzene, a liquid having a specific heat between benzene and carbon tetrachloride, showed no such irregularities, the specific heat-temperature curve being a straight line. Other physical properties such as vapour pressure and density, carefully determined over the same range of temperature, exhibited no similar irregularities. They find that water catalyses the change from one molecular species to the other in the case of benzene and ethyl benzene, and suggest that differential specific heat measurements of liquids offer an excellent method for the study of association. W. C. S. P.

2802. *Investigations on Specific Heats at Low Temperatures.* **F. Lange.** (Zeits. phys. Chem. 110. pp. 343–362, 1924.)—The author has carried out

investigations of the specific heats of hydroquinone, quinone, quinhydrol, tungsten, and white and grey tin, use being made of an adiabatic calorimeter. The substance under observation was placed in a copper calorimeter and was heated by means of a constantan wire (0·03 mm.) having a resistance of about 1500 ohms, wound on an insulated copper former. The electrical energy input was measured and a lead resistance thermometer was used to measure the rise in temperature of the material. A number of determinations were made at various temperatures between about 15° and 291° absolute. The results for hydroquinone, quinone, and quinhydrol show that the specific heat varies approximately proportionally with the temperature. Determinations of the specific heat of white tin and iodine were also made over the range 9°–14° absolute by means of the apparatus of Simon and Lange. The author's calculation of the chemical constant of diatomic iodine vapour gives the value $3 \cdot 37 \pm 0 \cdot 20$. For tungsten he obtains the value $3 \cdot 68 \pm 0 \cdot 72$. His results also confirm the Nernst theory of heat with respect to the allotropic transformation of tin. W. C. S. P.

2803. *The Revised Form of Trouton's Law of Latent Heat and the Quantum Theory.* **A. Byk.** (Zeits. phys. Chem. 110. pp. 291–317, 1924.)—On the basis of a quantum theory of corresponding states developed by the writer a formula due to Nernst for the revised form of Trouton's law is developed. This formula gives a satisfactory explanation of the quotient of the latent heat and the absolute boiling-point for volatile liquids. A. A. D.

2804. *Determination of the Constant σ of the Stefan-Boltzmann Law.* **A. Kussmann.** (Zeits. f. Physik, 25. 1. pp. 58–82, 1924.)—This is a very full and detailed account of the author's 153 determinations of the value of σ. The mean value finally obtained is $5 \cdot 795 \cdot 10^{-12}$ watt. cm.$^{-2}$ grad.$^{-4}$. The paper is divided into the following sections: (1) Historical Sketch of the Methods. (2) Arrangement of Experiment. (3) Preliminary Experiments to Ensure Absence of Systematic Errors. (4) Measurements and Result. (5) Corrections: (*a*) Imperfect Blackening of Receiver; (*b*) Absorption of Radiation by Atmospheric Moisture. (6) Limits of Error. The method employed by the author is that of electrical compensation, which consists briefly in having a suitable black body radiator which sends radiation through an aperture of known size to a receiving disc of metal of known size, the temperature attained by the disc being indicated by a radio-micrometer. The black body is shut off, and the metal disc is now heated by an electric current, which is adjusted so that the radio-micrometer shows the same reading. The current is carefully measured as well as the P.D. across the disc. Then we have

$$\sigma = \frac{I^2 w}{(T_1^4 - T_2^4)\frac{F_1 F_2}{R^2}\alpha} \frac{\text{watt}}{\text{cm.}^2 \text{ grad.}^4}$$

where I = current, w = resistance of disc, T_1 = temperature of black body, T_2 = temperature of disc, F_1 = area of disc, F_2 = area of aperture of black body, R = distance of black body from disc, and α is a correction constant. T. B.

2805. *On the Theory of Gas Degeneration (Gasentartung) and the Zero-point Energy.* **K. Bennewitz.** (Zeits. phys. Chem. 110. pp. 725–767,

1924.)—After some preliminary remarks on Nernst's heat theorem, the author sets out to find the general equation of state of a "degenerated" ideal gas which satisfies the two laws of thermodynamics and Nernst's heat theorem (called the third law). Nernst had obtained as an energy equation

$$U = \tfrac{3}{2}RT\tfrac{1}{2}x \cdot \frac{e^x + 1}{e^x - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where $x = \dfrac{\beta v}{T} = \dfrac{h^2 N^{2/3}}{4\pi m k} \cdot \dfrac{1}{T v^{2/3}}$, N = Loschmidt's number, v = mol. volume, U = energy per mol.

The author proposes another method not based on special assumptions of a theoretical quantum character. Classical statistics gives for an ideal gas the relation

$$pv = \tfrac{2}{3}U \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

We want to show that (2) in combination with the three laws leads to an energy equation which does not contradict (1). Now classical theory gives $U = \tfrac{3}{2}RT$, which combined with (2) gives $pv = RT$. Consider now an isothermal change from v_1 to v_2. External work

$$A = -\int_{v_1}^{v_2} p\,dv = RT \log \frac{v_1}{v_2} \quad \text{and} \quad \frac{\partial A}{\partial T} = R \log \frac{v_1}{v_2}$$

But the third law requires $\lim. \dfrac{\partial A}{\partial T} = 0$ $(T = 0)$; this is not satisfied, and therefore our premise must be insufficient. If we make the general supposition that $U = \tfrac{3}{2}R\phi(T, v)$ and $pv = R\phi(T, v)$ we can deduce that

$$-R\int_{v_1}^{v_2} \frac{\phi}{v}\,dv - \tfrac{3}{2}R[\phi]_{v_1}^{v_2} = -RT\int_{v_1}^{v_2} \frac{\partial \phi}{\partial T} \cdot \frac{dv}{v}$$

whence $\phi + \tfrac{3}{2}v\dfrac{\partial \phi}{\partial v} = T\dfrac{\partial \phi}{\partial T}$, the general integral of which is $\phi\left(T \cdot v^{2/3}, \dfrac{\phi}{T}\right) = 0$, where ϕ is an arbitrary function. This can be written $\phi = T \cdot \psi\left(\dfrac{C}{T \cdot v^{2/3}}\right)$, where ψ is a new function, and finally

$$U = \tfrac{3}{2}RT\psi\left(\frac{C}{Tv^{2/3}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

and

$$pv = RT\psi\left(\frac{C}{T \cdot v^{2/3}}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The author now shows that these equations are general enough to include those developed from special quantum considerations. The discussion of these equations occupies the greater part of the paper. A table of important thermodynamic relations giving the classical values for an ideal gas and the values for a degenerated gas is constructed. Entropy and chemical constants are found, and a complete proof of the statement that "the finite value of the vapour pressure lends necessarily to the degeneration of a gas." The limiting values of $\psi\left(\dfrac{C}{T \cdot v^{2/3}}\right)$ are now investigated and the energy values at zero temperature calculated. A table is given showing the values of the chief functions for the cases

$T = 0$ and $T = \infty$ on the classical theory and also for the case of degeneration with and without zero-point energy. From the results in the table the author assumes that the correction arising from the degeneration of a gas compared with the classical theory vanishes in the limit for large values of T. This is really an extension of Bohr's Korrespondence principle to gases. A proof of the principle can only be obtained experimentally. The grounds for the existence of energy at zero temperature are discussed. Nernst's method of arriving at the existence of zero-point energy or athermic energy is also discussed. A close parallelism between Nernst's heat theorem and the existence of zero-point energy is shown to exist. The Korrespondence principle is now employed in order to obtain a clearer view of the nature of degeneration in a gas. It is now shown that (4) can be written in the form $pv = RT\left(1 + \frac{\text{athermal energy}}{\text{thermal energy}}\right)$, which holds universally on the assumption of the Korrespondence principle. The integration of the Clausius-Clapeyron equation is discussed, and shown to have a physical meaning only when zero-point energy exists. The latent heat of evaporation λ for a degenerated gas vanishes at $T = 0$, while on the classical theory it has a finite positive value. The paper must be consulted for details. T. B.

2806. *Surface Fracture Figures Produced in Glass by Thermal Means.* **E. Berger.** (Archiv f. Elektrot. 13. pp. 187–188, July 7, 1924.)—E. Möller has shown [see Abstract 953 (1924)] that if a short circuit be produced between a sheet of tinfoil laid on the surface of a piece of glass and a second electrode brought into contact with the foil, the surface of the glass is destroyed in the region occupied by the melted foil and presents a series of furrowed lines forming an "electrical short-circuit figure"; Möller has given a theory of the production of these figures in the latter part of his paper. The object of the present article is to describe some experiments having a bearing on this theory of short-circuit figures. It is shown that figures resembling those produced by Möller can be made by purely thermal means. Pieces of glass with flat surfaces were tested in the following way: a flat face was held for 1 or 2 seconds in the pointed flame of an oxyhydrogen blowpipe and then immediately quenched in water. Ordinary window glass almost always flew in pieces under this treatment; the behaviour of hard or optical glass was different. After a moment, sometimes without quenching and sometimes after first tapping the glass with a hard object, the surface split up with an audible crackle, the fracture resembling closely the Möller figures. It is concluded as a result of the microscopical examination of the surfaces that the production of electrical short-circuit figures can be explained as a purely thermal phenomenon arising from the sudden melting and cooling of the surface combined with the property of glass to break with conchoidal fracture under shock. Tests on bakelite showed different results for, though this material is glassy, it does not melt but decomposes and carbonises before the blowpipe flame. B. H.

2807. *Atomic Heat of Silver at High Temperatures.* **A. Magnus** and **A. Hodler.** (Zeits. phys. Chem. 110. pp. 188–191, 1924.)—The atomic heat of silver may be represented by the equation $C_p = 6{\cdot}047 + 7{\cdot}49 \times 10^{-4}t + 7{\cdot}12 \times 10^{-7}t^2$. Since the temperatures at which the results included in this equation were obtained had for their lower limit the

ordinary room-temperature, the agreement between the value at 0°, 6·047, and Nernst's value, 6·00, must be considered satisfactory. The dependence of C_v on the temperature is expressed approximately by a straight line of the equation, $C_v = 5{\cdot}861 - 0{\cdot}00254T$. Hence, as the temperature rises, the atomic heat of silver increases to a maximum and then diminishes. An explanation of this behaviour is suggested on the basis of Born and Brody's theory [Abstract 1154 (1922)]. T. H. P.

2808. *Small Variations of the Heat Given Off by Radium Bromide.* **J. H. le Bel.** (Comptes Rendus, 179. pp. 160–161, July 21, 1924.)—In measuring the heat produced by different samples of radium, the author has found certain irregularities in the deflection of the galvanometer connected with the thermoelectric couple; this was in general, for the samples employed, about 40 cm., but once or twice a month it diminished by 10 to 15 mm. The second sample behaved like the first, the times of the minima coinciding. The walls of the cellar in which the experiments were made showed no signs of radio-activity. H. N. A.

2809. *Evidence of Association in Carbon Dioxide from the Joule-Thomson Effect.* **F. G. Keyes.** (Am. Chem. Soc., J. 46. pp. 1584–1592, July, 1924.)—It has been shown that the Andrews data for CO_2 can be represented by the equation $p = RT/(v - \beta e^{-\alpha/v}) - A/(v + l)^2$. Hence, assuming α and l negligible,

$$p = [R(1 - y/2)T]/(v - \beta) - A/v^2 \quad \ldots\ldots\ldots\ldots\ldots (1)$$

The fraction associated enters, at low pressures only, through the term $R(1 - y/2)$ where y is this fraction. Forming the derivative $(\partial v/\partial T)_p$ there results on substitution in the general thermodynamic equation for the Joule-Thomson effect (μ or dT/dp)

$$C_p\mu = 2A/RT - \beta - (\partial y/\partial T)_p \,.\, vT/2 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where v is written for $v - \beta$. The application of thermodynamics to a gaseous reaction of the type $CO_2 \rightleftharpoons \frac{1}{2}(CO_2)_2$ leads to the equation $(\partial y/\partial T)_p = -2y\Delta H_p/RT^2$, where ΔH_p is the heat of reaction at T and constant pressure. Substituting in (2), where $C_p\mu_0$ represents $2A/RT - \beta$, gives

$$C_p\mu = C_p\mu_0 + \Delta H_p \,.\, y/p \quad \ldots\ldots\ldots\ldots\ldots (3)$$

The Joule-Thomson effect, then, in a gas containing a small fraction of associated molecules, consists of the normal effect due to the deviation from the perfect gas laws for the single molecular species, to which must be added a change in temperature with pressure due to a small shift in the molecular species.

The author has employed the equations above in order to deduce the value of y (the fraction associated) from recent determinations by Burnett [Abstract 1514 (1924)] of the Joule-Thomson effect for carbon dioxide at pressures of about an atmosphere. The values of y are found to be small, corresponding to 1 double molecule in 500 at − 53° C. and 1 in 20,000 at 127° C. It is emphasised that the deductions are based on the assumption that true chemical equilibrium exists at every stage in the effect. T. B.

2810. *Notes on the Kinetic Theory of Viscosity, Conduction and Diffusion.* **S. Chapman** and **W. Hainsworth.** (Phil. Mag. 48. pp. 593–607, Sept., 1924.)—Pidduck's theory of viscosity and thermal conduction in poly-

atomic gases [Abstract 1653 (1922)] is generalised with the aid of a molecular model which takes account of the varying distance of closest approach between molecules depending on their relative speed of impact. It is assumed that the radius of gyration, k, of the molecule is invariable, whilst the change in the distance of closest approach occurs in the region beyond that in which the mass is distributed. The collision radius, a, is equated to σ/x, where σ is a constant and x a variable, which may be a function of any invariant of a molecular encounter. The following expressions are then deduced as first approximations for the values of thermal conductivity, λ, and the viscosity, μ, of a polyatomic gas, $\lambda=3(R^3T/\pi m)^{1/2}f_1(T)/64K'\sigma^2$, and $\mu=15(mRT/\pi)^{1/2}f_2(T)/32K'\sigma^2$, in which R denotes the usual gas constant $1\cdot35\times10^{-16}$, T is the absolute temperature, m the molecular mass, $K'=k^2\sigma^2$, whilst $f_1(T)$ and $f_2(T)$ are expressed as complicated integrals which, in general, are functions of T. Values of the ratio $\lambda/\mu C_v$, C_v denoting the specific heat of the gas at constant volume, and of the variation of viscosity with temperature, calculated by means of these formulæ, are shown to agree more closely than has hitherto been the case with the observed results for various diatomic and polyatomic gases. The definition of temperature in the non-steady state of a polyatomic gas is discussed, and it is pointed out that the definition used by Jeans ($3RT/2=m\bar{C}^2/2$) is to be preferred to that used by Pidduck ($NRT/2=\bar{E}$), as the former avoids the introduction of a small additional term, proportional to the time rate of change of density in a small volume moving with the gas, in the usual expression, $p=nRT$, for the hydrostatic pressure. A formula for the coefficient of diffusion appropriate to a polyatomic gas is deduced, and revised formulæ and tables for various quantities connected with thermal diffusion in a monatomic gas correcting values previously published are given. In particular it is pointed out that the revision brings calculated values of thermal diffusion into somewhat closer agreement with the experimental results obtained by Ibbs in Abstract 1999 (1921). [See Abstract 794 (1916).] J. S. G. T.

2811. *Statistical Entropy and Molecular Number.* **L. Nordheim.** (Zeits. f. Physik, 27. 1. pp. 65–73, 1924.)—The author calculates the statistical entropy of a compound system having regard to the possibility of exchange of molecules as a function of the entropies of the component systems; the analogy to the law of thermodynamic entropy is pointed out. The result obtained is that if the entropies are divided by the log of the exchange-number, then the law of additivity is obtained just as in thermodynamics. The paper is entirely mathematical. T. B.

2812. *Planck's Law and the Light Quantum Hypothesis.* **Bose.** (Zeits. f. Physik, 26. 3. pp. 178–181, 1924.)—A method is given for the establishment of Planck's law by the utilisation of the light quantum hypothesis in combination with mechanical data and which is independent of the classical theory. The phase space of a light quantum in relation to a given volume is divided into "cells" of magnitude h^3. The number of possible divisions of the light quanta of a particular radiation into these "cells" determines the entropy and also all the thermodynamic characteristics of the radiation. The formula finally deduced is the equivalent Planck's law. A note, in conclusion, by Einstein suggests the use of the method for the application of the quantum theory in the case of an ideal gas, and promises further remarks by him later on this aspect. S. G. B.

2813. *Coordination of the Thermodynamical Properties of Water.* **A. Lartigue.** (Comptes Rendus, 179. pp. 30–33, July 7, 1924.)—In a preceding paper [Abstract 2552 (1924)] Fresnel's method of representation has been utilised in the development of certain thermodynamic relations. In the present paper some of the thermal characteristics of water are evaluated—in particular the latent heat—and the results compared with the values given by Regnault and by Henning. There is also some information relating to the specific heat of ice. A. A. D.

2814. *The Liquefaction and Rectification of Air.* **L. D. Goldsmith.** (World Power, 2. pp. 29–37, July, and pp. 108–112, Aug., 1924.)—The paper gives a clear elementary account of modern methods for the liquefaction of air and the separation of constituents, oxygen, nitrogen, argon, neon, krypton, and xenon.

It also contains a number of useful references to the literature.

E. G.

2815. *Annealing of Aluminium.* **H. Röhrig.** (Zeits f. Metallkunde, 16. pp. 265–270, July, 1924.)—A series of experiments were made to investigate the relationships between the velocity of softening, the degree of softness of aluminium, and the effect of time and temperature upon the degree of annealing. The tensile strength, elongation, and grain size were also discussed, and it was found that definite conditions must be adhered to for the best treatment of aluminium.

It was found that one means of avoiding the critical temperature for grain growth was to raise the temperature of the metal as rapidly as possible. The good heat conductivity of aluminium assisted the rapid heating. Further, the magnitude of the charge had an influence on the rapidity of heating owing to the high specific heat of aluminium. It is laid down that the use of small bundles of material for annealing assist in ensuring the production of fine crystallisation, which is necessary for aluminium sheet when required for further working. F. J. B.

2816. *The Cementing of Small Pieces of Iron.* **D. Uno.** (Kyoto Coll. Sci., Mem. 7. pp. 107–124, March, 1924.)—A bundle of iron wires, containing carbon, which were of definite cross-section, were packed in a glass tube with Caron's cement [composed of ($BaCO_3$), and carbon] and heated in an electric furnace to various temperatures ranging between 800° C. and 1000° C. It was proved that the degree of cementation depended on the temperature to which the tube was subjected and also on the time period of heating. Size of cross-section of the iron wires also had a definite influence, and in this connection a factor f_Q which indicates the relative cementation ability or power with cross-section was deduced from the experimental results. A model was constructed to show the connection between the various factors involved—*viz.* temperature-time, cross-section, percentage of carbon present—from experimental observations. The cementing powers of barium carbonate and calcium carbonate were compared. The paper contains tables and curves showing all results of experiments and all details of practical procedure.

S. G. B.

SOUND.

2817. *Nature and Artificial Production of Consonant Sounds.* **R. A. S. Paget.** (Roy. Soc., Proc. 106. pp. 150–174, Aug. 1, 1924.)—In a previous paper experiments were described in which the author's English vowel sounds were reproduced by means of double resonators tuned to give the two principal audible resonances heard when whispering or breathing the vowels in question [Abstract 1908 (1923)]. It was found that various consonant sounds could be produced by manipulating these models, as had been done previously by others in the case of a single resonator.

This led to the construction of other plasticine (and rubber) models with three (or four) resonators and in series or with combinations of series and parallel arrangement. On tuning these models and suitably manipulating them by full or partial closure and release many consonants are obtained. So that the conclusion seems justified that all the consonant sounds are as essentially musical as the vowels, *i.e.* that they depend on variations of resonance in the vocal cavity, and should be capable of being imitated in the same way if their characteristic resonances could be identified and reproduced in models.

The subject is then developed in detail, all the ordinary English consonants being dealt with, and also the guttural *r* (Northumbrian), the Scots and German *ch* (as in lo*ch* and Bu*ch*), and the Welsh *ll*, which is described as an unvoiced *l*, with the addition of an aspirated resonance, as in *h*.

As a specimen of the results obtained we may give the analysis for *m*. This was found to have the following resonances: (1) A faint upper resonance, 2434 to 2579 per sec.; (2) an oral resonance of 861 to 1722, varying with the upper resonance of the associated vowel; (3) a nasal resonance of 1217 to 1448, also varying with the associated vowel; and (4) a constant lower-throat resonance of about 271, varying one or two semitones according to the elevation of the chin.

In the analysis of the terminal resonances of *k*/*g* and *t*/*d* respectively, it is found there is no general principle of resonant change characterising these two types of consonant when used with different associated vowels, except the greater rapidity of closure for *t*/*d* than for *k*/*g*. This absence of any general characteristic resonant change is held to indicate that, in identifying these particular consonant sounds, and probably also in identifying *all* speech sounds, the ear is primarily concerned in recognising *where* and how the closure (or release) is made in the vocal cavity, rather than in identifying the actual resonant changes themselves. This conclusion is confirmed by the observations of the author and others on the vowel sounds, from which it appears that, in the case of voiced vowels sounded on a succession of different larynx notes, there are no particular components common to the same vowel when sounded with different frequencies of larynx note. What the ear hears, in each case, is the general effect on the larynx note of the resonant characteristics of the cavities through which that larynx note has passed, which characteristics are due to the relative volume and areas of orifices produced by the different attitudes of the tongue and lips. In other words, human speech appears to be essentially a branch of human gesture, which the ear has learnt to identify —without the aid of sight—by means of its secondary effects in modifying the resonances produced by the passage of air by or through the gesticulating members of the vocal cavity. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

2818. *Specific Inductive Capacity in Solids.* **J. Errera.** (Comptes Rendus, 179. pp. 155–158, July 21, 1924.)—The variation of specific inductive capacity in a Hertzian field throws light upon the movements in polarisation. In air there is no such variation; in solids there is. It appears that there are two phenomena causing specific inductive capacity to be distinguished: (1) The movement of particles (atoms, molecules, ions), determined by the applied field, by elastic forces, or by thermal agitation, by the inertia of the particles and by viscous resistances; and (2) the movement of electrons within each particle, producing or modifying a state of polarisation. The former, at a given temperature, is hampered by a high frequency, and under a given frequency it is less well marked the lower the temperature. The latter is much less affected by the frequency and is practically independent of the temperature, and it is in any case relatively small. At very low temperatures or very high frequencies the latter alone remains; at high temperatures the latter assumes high values. The specific inductive capacity therefore falls off, like the specific heat, as the temperature is reduced. A. D.

2819. *On the Problem of the Electrical Charges of Sub-Microscopic Particles. II.* **T. Sexl.** (Zeits. f. Physik, 26. 6. pp. 371–378, 1924.)—The present paper contains a revised mode of calculation for the Derieux data [see Abstract 454 (1918)] compiled by the Ehrenhaft-Millikan method with respect to the fall period of mercury drops at different pressures. This has afforded not only a determination of particle size free from objection, but also a constant of the Stokes-Cunningham resistance law which deviates appreciably from that given by Millikan for mercury-air. Since this necessitates deviations in the particle charges from electronic values, Ehrenhaft's conclusion appears to be confirmed, *viz.* that charges are stable upon microscopic and submicroscopic metallic particles in a similar manner to those on dielectric particles. H. H. Ho.

2820. *Contact Electricity.* **A. Coehn** and **E. Duhme.** (Zeits. f. Physik, 27. 5-6. pp. 358–383, 1924.)—The charge on the bubbling of gases through liquid metal is independent of the nature of the gas. The only function of the gas is to break up the double layer always existing within the surface of the liquid and to carry charges with it. With non-metallic liquids the bubbling gas carries off negative charges; with pure mercury, positive, positive ions being allowed to escape with the gas and electrons retained. The sign of the escaping charge is reversed by the addition of traces of certain metals to the mercury, and its quantity greatly increased. The noble metals (Sn, Cu, Ag, Au) do not produce this effect. A. D.

2821. *Quantitative Theory of the Influence Electrostatic Generator.* **A. W. Simon.** (Nat. Acad. Sci., Proc. 10. pp. 302–304, July, 1924.)—A rigorous quantitative theory of the influence electrostatic generator has

never been given. Maxwell worked out a special case—that of the Kelvin replenisher—but his solution is only an approximation, for he has assumed that the carriers give up all their charges to the inductors, and further, has neglected the fact that each element of the machine is influenced by all the other elements. The present author has developed a mathematical treatment, which can be applied to any static machine, and which is not subject to the criticisms mentioned above. The method of attack consists in (1) writing the equations for the charges on the elements of the machine in terms of the potentials, the coefficients of capacity, and the coefficients of induction of the elements for each of these configurations of a complete cycle in which a change of charge occurs on any of the elements. To these equations are added a number of others involving the charges only, and wholly expressing conservation of quantity of electricity. Leakage is neglected. (2) From this basic group of equations all the charges are eliminated, and a number of simultaneous equations obtained, each of which gives the potential of a particular element at, say, the beginning of the $(n + 1)$st cycle in terms of the potentials of a certain number of the elements at the beginning of the previous, the nth, cycle. (3) From this second group of equations there is deduced a number of additional equations giving the potentials of the same elements at the beginning of the $(n + 2)$nd, $(n + 3)$rd, up to the $(n + m)$th cycle. (4) From the latter set, by elimination, a final set of equations is deduced, each of which involves only the potentials of a single element over a number of successive cycles, and of which is therefore of the form: $Vn + m + k_1 Vn + m - 1 + \ldots + km Vn = 0$, where k_1, k_2, etc., are certain combinations of the coefficients of capacity and coefficients of induction involved in the basic set of equations, and $Vn + m$ is the potential of a certain element at the beginning of the $(n + m)$th cycle. Each one of these equations expresses the potential of a given element in the form of a recurrent sequence, which can be evaluated by the calculus of finite differences.

H. H. Ho.

2822. *Electromotive Force of Filtration.* **L. Riéty.** (Comptes Rendus, 178. pp. 2246–2247, June 30, 1924.)—The flow under high pressure of even concentrated salt solutions through a capillary tube produces between the ends of the tube an e.m.f. proportional to the pressure difference and diminishing as the concentration of the solution increases. With some solutions, such as those of copper sulphate, the potential at the exit of the tube is higher than at the entrance, whereas with others, such as those of copper nitrate, the reverse is the case. If the flow of the liquid is continued for some days, the e.m.f. diminishes with salts of the former class and increases with those of the latter, tending towards a limit in either instance.

T. H. P.

2823. *An Electrical Method for Tracing Stream Lines in the Two-Dimensional Motion of a Perfect Fluid.* **E. F. Relf.** (Phil. Mag. 48, pp. 535–539, Sept., 1924.)—Use is made of the fact that the stream lines for flow past an obstacle are coincident with the equipotentials for a conductor of the same shape in an electrostatic field. This coincidence is practically unaffected if the dielectric has a small conductivity. The model was placed in a rectangular tank full of water, and containing two sheets of aluminium mounted on its longer sides. Alternating current of audible frequency was supplied to the sheets, and two electrodes, one

fixed, the other movable and attached to a pantagraph which allows its position to be recorded on a sheet of paper, dip into the water. These electrodes are connected to a low-frequency amplifier and a telephone. By moving the one electrode to a succession of points for which the sound in the telephone vanishes, a series of points on an equipotential, *i.e.* a stream line, is obtained. By moving the other electrode and repeating the process the whole field is rapidly mapped out. Comparison with the known results for flow round a flat plate showed that the method is sufficiently accurate to be of practical use. W. G. B.

DISCHARGE AND OSCILLATIONS.

2824. *Discharge Tension in Water-Vapour.* **I. Strohhäcker.** (Zeits. f. Physik, 27. 1. pp. 83–88, 1924.)—An experimental arrangement is described in which the spark track between ball terminals is shielded from disturbing influences, and by its means the spark tension in pure unsaturated water-vapour and in very dry air is determined. In order that the phenomena may be easily reproducible it is essential that the electrode surfaces shall be absolutely free from fat. The spark-tension curves obtained with water-vapour deviate from the known form. A. E. G.

2825. *The Luminous Discharge in Chlorine. The Electron Affinity of Halogen Molecules.* **W. A. Noyes, Jr.** (Am. Chem. Soc., J. 46. pp. 1598–1606, July, 1924.)—In a recent article [see Abstract 1639 (1923)] it was shown that the potential necessary to maintain a luminous discharge in bromine is of the same order as that necessary in the case of iodine, and that the potentials for these two electronegative gases are higher than in the case of electropositive gases such as hydrogen and mercury. It was suggested that this fact could be accounted for without assuming that the halogen molecules as such possessed an electron affinity. The halogen atoms have definite electron affinities which increase from iodine to chlorine. In the arc, however, the conditions are very far from equilibrium and the concentrations of the monatomic halogen atoms are very difficult to estimate. It was pointed out that since the heat of dissociation of bromine is higher than that of iodine, the concentration of the former as monatomic gas might reasonably be expected to be lower than the concentration of monatomic iodine, a fact which would counterbalance, to a certain extent, its larger electron affinity. In the present paper a full account of experimental procedure is given, and the apparatus used is illustrated diagrammatically. It is found that the luminous discharge in chlorine usually disappears at some multiple of 8·2 volts plus a small correction. It is shown by thermodynamic reasoning that the halogen molecules may take up electrons according to the reaction $X_2 + 2e = 2X^-$. The free-energy change is large and negative, which probably means that the electrons must attain ionising speed in a shorter distance than the mean free path. Certain points are obtained at some multiple of the ionisation potential plus 4·0 volts. This corresponds to a strong absorption band in chlorine, and it is suggested that this may be one resonance potential of chlorine. The relation of the ionisation potentials of iodine, bromine and chlorine to one another is discussed. It is suggested that the point at 8·2 volts in case of chlorine corresponds to the formation of a molecular ion. A. E. G.

2826. *The Beginning of the Glow Discharge in Hydrogen and Air.* **K. Oelkers.** (Ann. d. Physik, 74. 8. pp. 703–721, Aug., 1924.)—The experiments of Reiche [see Abstract 537 (1917)] on the appearances which precede the true glow discharge are here repeated, the utmost precaution being taken to avoid all traces of fat vapour. The experimental arrangement is described in detail, and diagrams showing the complete arrangement of apparatus, the discharge vessel, the drying apparatus and the hydrogen apparatus are given. Experiments with aluminium electrodes in hydrogen are first described. Curves are given which show (*a*) current-tension curves in H_2 at 7·4 mm. pressure, electrodes 2 mm. apart. (*b*) Current begins with alteration of tension of about 2 volts with Al electrodes in H_2 at 7·4 mm. pressure. (*c*) Current-kicks: Al electrodes in H_2 at 7·4 mm. pressure. (*d*) Al electrodes in H_2 at 7·4 mm. pressure, the beginning of the normal glow discharge. Experiments with aluminium electrodes in air are dealt with next, and current tension curves with Al electrodes, 2 mm. apart, in air at 7·4 mm. pressure are given. Lastly, experiments are described using electrodes of copper, steel and silver. Current-tension curves are given showing results obtained with copper electrodes, 2 mm. apart, in H_2 at 6·8 mm. pressure. A curve also shows the current variations with copper electrodes in H_2 at 6·8 mm. pressure, and other curves show kicks with very small currents when using copper electrodes in H_2 at 6·8 mm. pressure. An explanation of the phenomena described is built up by assuming the existence of electrical double layers.

A. E. G.

2827. *The Emission of Light in a Striated Discharge.* **R. Seeliger** and **J. Ôkubo.** (Phys. Zeits. 25. pp. 337–342, July 15, 1924.)—The distribution of intensity of light emitted in a striated positive column is investigated by means of spectrophotometric records for individual lines in the spectrum. The discharge tube used was 20 mm. in diameter and 35 cm. long, fitted with a capillary near the anode for admission of gas. The electrodes were of platinum. The tube is fitted with a mercury pump and McLeod gauge, and in order to prevent the presence of mercury vapour the leads are cooled in liquid air. The tube is maintained in an oven at 350° C. for some time, and thus completely cleaned and purified previous to use. The usual method of measurements with a microphotometer is used. Curves are given for investigations with helium, mercury, hydrogen, nitrogen, and various mixtures. The results obtained showed that, besides repeating several previously obtained phenomena and the confirmation of a law on series succession already found by Stark [Abstract 637 (1917)], a new connection is given between the distribution of the light emission in space and the excitement characteristics of the line. The intensity curve along the discharge exhibits shallow waves for all lines stimulated by slow electrons in the emission, whilst also all lines show deeper waves due to faster electrons. A possible interpretation of this connection between wave depth and the exciting function is given by the hypothesis that in the striated column not only the slow electrons move with periodic change of velocity and current density, but that besides this a current of faster electrons flies through the striation.

S. G. B.

2828. *Explanation of Abnormal Low Voltage Arcs.* **K. T. Compton** and **C. H. Eckart.** (Nature, 114. p. 51, July 12, 1924.)—It is well

established that arcs in gases or vapours may be maintained at voltages as low as their ionising potentials, or, in cases where cumulative ionisation is possible, as low as their radiating potentials, provided a hot kathode is used as a source of electrons to stimulate the arc. Considerable discussion has arisen over certain cases in which arcs have been maintained at still lower voltages [see Abstract 1684 (1922)], since at such voltages the electrons are known not to effect partial or complete ionisation of molecules with which they collide. Recently Bar, v. Laue, and Meyer and, independently, the present writers, have shown that this may be accounted for by the existence of oscillations, the peak voltage of which always exceeds the lowest radiating potential of the gas. An experimental and theoretical study of these oscillations has shown them to be in the nature of current interruptions occasioned by the rise in current and consequent drop in voltage occurring when the ionisation is sufficient to create a positive space charge around the filament. The above phenomenon does not explain all cases of abnormal low-voltage arcs, however, for the authors have maintained arcs in helium, mercury-vapour and argon, without oscillations, at voltages well below the lowest critical voltages of the gases. Also Holst and Oosterhuis have reported steady arcs in argon at 3·5 volts and neon at 7·5 volts, whereas the lowest critical potentials of these gases are 11·5 and 16·7 volts respectively. To account for this these authors have proposed a rather elaborate theory of progressive ionisation. The following experiments, however, explain entirely these abnormally low voltages simply on the basis of well-known phenomena. A short hot-filament kathode and a sheet nickel anode are placed about 1 cm. apart, and a 3-mm. length of 1 mil wire projecting from a glass stem is introduced as an exploring electrode in a bulb filled with pure argon at 2-mm. pressure. It is found that the arc can be maintained at an applied voltage of about 4 volts, without oscillations. Under these conditions, however, the gas near the filament is found to be at a potential of about 11·5 volts above that of the filament, and there is an electric field in the direction reverse to the applied field throughout most of the space between the electrodes. Furthermore, the concentration of ions, either positive or negative, is found to decrease from about 100×10^{10} per c.c. near the kathode to about 2×10^{10} per c.c. near the anode. The average kinetic energy of the electrons outside the region of the kathode drop is found to vary from 2 to 4 in equivalent volts. Analogous results are found in a mercury arc, operating at about 3·5 volts. Evidently there is always a sufficient kathode drop to produce ionisation. A fuller treatment of this problem and its significance in the Geissler tube discharge will be published shortly. A. E. G.

2829. *The Existence of a Light Arc with a Non-Incandescent Kathode.* **H. Stolt.** (Zeits. f. Physik, 26. 2. pp. 95–101, 1924.)—Investigators who have sought to explain the behaviour of the arc have proclaimed that a white incandescent kathode is inevitable. Stark and Cassuto lent support to this view when they failed to establish an arc light between a fixed anode and a brass kathode cooled by rotation. The experiments recorded here show that, by utilising a highly polished brass or copper disc 1 cm. thick and 16 cm. diameter, which is rotated at a small distance between the electrodes, an arc is established, and the kathode is apparently non-incandescent. The arc and kathode were observed through a spectroscope and the non-incandescence apparently confirmed. For a potential

of 220 volts a table of results is given showing current strength, voltage, linear velocity of kathode circumference, and the electrode separation distance. A discussion of these tables and a note on experiments performed with various other metals is appended. The investigation shows the great probability that the electrons in the arc are discharged without a high temperature of the kathode. S. G. B.

2830. *A Simple Demonstration Experiment of the Direct Measurement of the Velocity of Kathode-Rays.* **F. Kirchner.** (Phys. Zeits. 25. pp. 302–303, June 15, 1924.)—The method described is a modification of that due to Wiechert. A diagram illustrating the process is given, but the explanation is confined to points of difference between this and the original Wiechert method. A. E. G.

2831. *The Thermal Effect of Kathodic Plate Current in the Mercury Vapour Discharge.* **W. Schottky** and **J. v. Issendorff.** (Zeits. f. Physik, 26. 2. pp. 85–94, 1924.)—An examination is made of the current which passes between a mercury discharge column and a surrounding cylindrical metal electrode maintained at definite potentials. Reference is made to the earlier views which have been put forward to account for the nature of the ionising current and to the work of Langmuir on space potentials [Abstract 618 (1924)]. The positive current is stopped by a potential of $12 \cdot 2$ volts, attains a saturation value with about -1 volt and from here to -600 volts is approximately constant. To ascertain the nature of the discharge a determination is made of the heat imparted to the surrounding electrode by the discharge when different potentials are applied. With the arresting potential of $12 \cdot 2$ volts, the temperature of the electrode is raised by means of a surrounding heating coil until it is at the same degree as that given by the ionisation current at different potentials in the absence of the auxiliary heating current. Over a range of potentials from -1 to -110 volts a linear relation is found for the expression $L = EJ$, where L is the heat effect in watts, E the applied potential, and J the ionisation current. From this formula and the heat generated, J is calculated to have the approximately constant value of $0 \cdot 041$ amp., while the measured ionisation current is $0 \cdot 038$ amp. This result indicates, in accordance with Langmuir's calculation, that beyond a certain potential the whole of the remaining potential fall is situated in the immediate vicinity of the electrode. A consideration of the free paths of atoms and electrons indicates that the current is conveyed almost entirely by positive ions and only to a very small extent by electrons. It is estimated that the electronic current does not exceed 20 % of the total. It follows that no appreciable photoelectric effect or kathode-ray radiation, either primarily or secondarily by ionic bombardment, contributes to the conductivity. In the form of apparatus used the zone of potential gradient is visible as a distinct dark space. The break in the curves for thermal and ionisation values at p.d.'s between 15 and -1 volt is attributed to the energy change concerned in the absorption of the electrons in the metal. This consideration supports the view that the apparent potential indicated by a sounding electrode in contact with a mercury arc is about 5 volts below the true potential. This conclusion is also in accordance with the observation that the dark space indicating the zone of ionic potential gradient disappears when the cylindrical electrode is at a potential about 5 volts higher than that of an isolated sounding electrode [see Abstracts 1648 and 1938 (1923)]. J. N. P.

2832. *Gas Ion Mobilities and their Independence of the Nature of the Ion.* **L. B. Loeb.** (Phil. Mag. 48. pp. 446–458, Sept., 1924.)—A concise survey is given of the controversy between the classical theory of the "cluster ion" in gaseous ionisation phenomena and the "small ion" theory. The development of the case is fully treated, and finally a combination of the Thomson and Langevin equations is effected which furnishes a theory of ionic behaviour which predicts the behaviour of gaseous ions under various conditions with considerable accuracy. The final formula thus reached is :—

$$K = \frac{A\sqrt{\frac{1+b}{b}}}{\frac{p}{760}\sqrt{(D-1)M_0}}$$

where K is the mobility factor of the ion, A is a constant depending on the Avogadro number, the mass of a hydrogen atom and a numerical coefficient; b is derived by putting $m = bM$, where m is the mass of a complex cluster ion and M the weight of a molecule, $M = M_0 \mu$ where μ is the mass of an atom of hydrogen and M_0 is the molecular weight.

The paper proceeds to deal individually with the various factors involved, and concludes with a table giving a comparison of calculated and experimentally obtained values. It is noted that the computed mobilities are of the right order of magnitude, and do not differ widely from observed values. The deviation is greatest for vapours of high dielectric constant. It is seen from the formula that except for the factor $\sqrt{\frac{1+b}{b}}$ there is no quantity in the mobility equation which permits a discussion on the nature of the ion. The theories of Thomson and Langevin thus combined are used to effectively refute the "cluster ion" theory and to indicate the law of force exerted by the ion on the majority of gas molecules. The transformations involved practically eliminate any factor involving a specific hypothesis of the nature of the ion from the equation, and thus make it impossible from mobility measurements to decide upon the nature of the ions. S. G. B.

2833. *On Soft Atomic Rays.* **T. Volmer.** (Zeits. f. Physik, 26. 4–5. pp. 285–290, 1924.) Gossmann's recent work [see Abstract 1535 (1924)] has shown that a large number of salts emit positive charges at the relative low temperature of about 450°. Saturation appears at low voltages, *e.g.* for a pressure of 5 mm. at about 2 volts. This denotes apparently the presence of soft positive rays, and the object of the present paper is to confirm this assumption. For this purpose e/m has been determined. Lenard's method for photoelectrons was employed, and experimental details are described. The following substances were examined : cadmium, iodide, nitrate, and chloride, zinc chloride, copper iodide, lead bromide, sodium nitrate, and calcium fluoride. A table of results is included, showing these salts to emit positive atomic rays which are easily deflected.
H. H. Ho.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

2834. *Electric Conductivity of Metals.* **F. Simon.** (Zeits. f. Physik, 27. 3. pp. 157–163, 1924.)—The alteration in the electric conductivity

of metals on fusion and changes of pressure and temperature in the fused state can be explained by changes in the vibration-frequency of the atom, provided that the constant in the Grüneisen formula [Abstract 1273 (1918)] be made proportional to the frequency, which the author had previously [Abstract 2144 (1924)] deemed possible. The electrical conductivity of metals is a function of the temperature in solid and liquid metals and a function of the volume (changing with pressure or on fusion) without more than one electric constant which does not vary from substance to substance but depends only on the arrangement of the outer electrons. A. D.

2835. *Electrical Conductivity of Metals and Alloys on Bohr's Theory.* **K. Højendahl.** (Phil. Mag. 48. pp. 349–360, Aug., 1924.)—The valency electrons in a metal may be imagined as moving in a quantised zigzag path from one atom to another. A small displacement of one or more atoms will result in the general direction of movement being abruptly changed, and this will correspond to the ends of a free path on Drude's theory. The variation of free path in a pure metal will be a function of the temperature and will be of the correct form. The introduction of an atom of another element into the space lattice will also cause an abrupt deviation, and so will reduce the free path and increase the resistance. This theory is supported by a table showing the rise in resistance in iron containing equal numbers of foreign atoms. This quantity is nearly constant. It is possible to calculate the velocity of the electron in such a structure, and this appears to be of the right order. A. Wh.

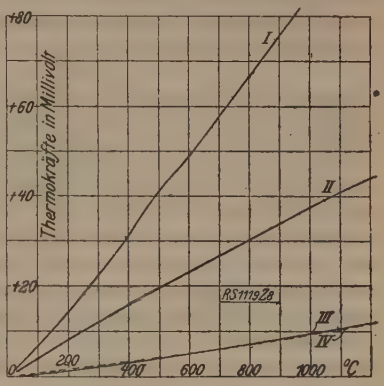
2836. *Investigations of the Electrical Conductivity of Flames Containing Metallic Vapours with Introduction of Field Measurements Free from Objection.* **E. Zachmann.** (Ann. d. Physik, 74. 6. pp. 461–517, July, 1924.)—Lenard in 1914 demonstrated almost all previous data in this field to be invalid, exceptions being certain measurements by Warburg, H. A. Wilson, and E. Gold [see Abstract 1067 (1907)]. The valid conditions are now published for the evaluation of the electrical conductivity of flames containing metallic vapours, electrode effects being eliminated. These are contained in Part I and are as follows: The current which enters the flame by one electrode must leave *via* the other electrode without loss, moreover the current-density must be equal over the entire length of the circuit. A place must therefore be present where equality exists between positive and negative carriers, *i.e.* neutrality of the flame as a whole. The presence of such a place is indicated by a field minimum. Part II considers the testing of various forms of electrode installation for the fulfilment of the above conditions, and it is shown that those in which the burner evolves a foreign body (upright plate and cylinder electrodes with horizontal burner orifice plane) afford no suitable field relationships (failure of the minimum) and exhibit dependence of current-density distribution upon voltage. Part III describes an arrangement free from objection with respect to field distribution, which is afforded by the orifice plane constituting one electrode and installed with a suitably constructed horizontal electrode. Exact determination of the current-density in the electrode plane is rendered by means of a guard ring. This electrode is cooled by a suitable device, and it is established that only in the flame volume are electrons produced for the conduction of electricity. Sources of error for small fields are discussed in Part IV, investigated,

and eliminated. The results of the conductivity measurements are as follows: (*a*) The conductivity of the alkali metal frames is proportional to the square root of the metallic concentration. Previous workers have found such a relationship, but as mentioned at the outset their methods are not free from objection and the present investigation now affords a valid proof. Also the conductivity of alkali metal flames (*b*) is proportional to the square root of the atomic weight of the metals; (*c*) is independent of the simultaneous presence of the vapour of another metal, and (*d*) exhibits strong temperature influence. From these results the following conclusions are drawn: (*a*) The electronic production in flames containing metallic vapours is proportional to the metallic content and ensues by impact of the metallic atoms with the flame molecules. Interaction between the metallic atoms could not be established, notwithstanding Andrade's conclusions as to metallic activity. (*b*) The emissivity constant of the alkali metals is proportional to the atomic weight, a result in agreement with earlier conclusions of Lenard. (*c*) It is shown that from the investigations of Ebert, Andrade, and Wilckens on the obliquity of the vapour bands in the electric field no objections can be raised against the conclusions now drawn. (*d*) The temperature dependence of the conductivity renders the Marx photoelectric hypothesis very improbable, although this gives the same concentration and atomic weight dependence of the conductivity as now established. The paper contains very copious experimental details, 11 tables of data, and 16 sets of curves.

H. H. Ho.

2837. *A Remarkable Property of the Positive Column of the Mercury Arc. Influence of External Sheaths.* **L. Dunoyer** and **P. Toulon.** (Comptes Rendus, 179. pp. 148-151, July 21, 1924.)—The phenomenon described is essentially a property of the positive column of mercury arcs fed by an alternating current. If around a part of the tube in which the positive column of this intermittent arc is produced a metallic sheath is placed, and if there is set up an alternating tension of the same frequency as that between anode and kathode, but of any phase chosen arbitrarily with respect to the latter, the following phenomena are then observed: Suppose first that the sheath is in the neighbourhood of the anode. If the tension sheath-kathode is in accord rephase with the tension between anode and kathode, the sheath provokes the passage of the arc, even when the pressure of the mercury vapour is too feeble for the arc to play spontaneously between anode and kathode without the sheath (positive effect). If the tension sheath-kathode is in opposition phase with that of anode-kathode, the sheath provokes the extinction of the arc (negative effect). If the phase of the sheath-kathode tension shows a delay on the phase of the anode-kathode tension, gradually increasing from the neighbourhood of 0 to about π, the mean current which passes in the arc diminishes gradually from its maximum value to zero. If the phase of the tension sheath-kathode shows an advance upon the phase of anode-kathode tension which gradually increases from 0 to π, the mean current which passes in the arc remains constantly equal to its max. value. When the sheath is in the neighbourhood of the kathode, the circumstances of the production of the positive and negative effects are inverted. Effects produced by replacing the metallic sheath by the hand are described. Conditions are also described in which the bulb acts as a relay of extreme sensibility and enormous power. A. E. G.

2838. *Thermoelectric Investigation of Nickel Alloys.* **W. Rohn.** (Zeits. f. Metallkunde, 16. pp. 297–300, Aug., 1924.)—The object of this investigation was to obtain a thermocouple suitable for commercial use up to temperatures in the neighbourhood of 1200° C. The materials for such a couple should be cheap, durable, and the thermoelectric force should be reasonably high so as to avoid measuring instruments of great sensitivity. With this object in view, an investigation of the variation of the thermoelectric force of the metals Ni, Co, Al, Mg, Fe, Ta, Au, Cu, Ag, Mo, and W with Pt as the other element of the couple was first carried out over the range 0°–1200° C. The results are represented graphically in the paper, and it is concluded that Ni is the most suitable metal to employ as base for an alloy. Measurements were then made of the thermoelectric force, over the same temperature range, of Pt with binary alloys of Ni. The alloys used were Ni with 5 % of Al, Mn, Ti, Ta, Zr, W, Mo, Cr, and V, and 10 % of Cu, Co, Fe, W, Cr, Mo, and V. The data are represented graphically. From these curves it is deduced that combinations of Ni with Ni-Al or Ni-Cu or Ni-Fe might be used for ranges beyond 500°. For wider ranges combinations of Ni-Va, Ni-Cr, Ni-Mo or Ni-W, with either pure Ni or Ni-Al or Ni-Cu would be suitable. Va is excluded on account of the technical difficulty of obtaining it sufficiently pure, and Ni-Al alloys with more than 5 % Al are difficult to prepare. Then follows an investigation of the electromotive force of couples formed of Ni with 4, 8, 10 or 16 parts of Cr, 4, 8, 10, 12, 16 or 20 parts of Mo or W, and 10, 30, 50 or 70 parts by weight of Cu against pure Pt. From the curves coordinating these data it is inferred that suitable couples would be Ni-Mo (16 % Mo) against Ni-Cu (Cu 50 %). No. I in figure. Oxidation, however, sets in rapidly beyond 800° C. No. II represents Ni-Cr (9·5 % Cr) against Ni. No. III (full line) is the usual Pt Pt-Rh couple, and the broken line IV is a combination of two Ni-Cr alloys giving almost the same thermoelectric force.



L. L.

ALTERNATING CURRENTS AND MAGNETISM.

2839. *Magnetic Measurements on Materials of High Initial Permeability.* **P. P. Cioffi.** (Optical Soc. of America, J. and Rev. Sci. Inst. 9. pp. 53–60, July, 1924.)—Description of circuits and apparatus suitable for testing material such as permalloy. The specimen in the form of a long wire or tape is hung inside a long vertical tube carrying two magnetising coils wound side by side. A search coil at the centre is connected to a ballistic galvanometer. The galvanometer is calibrated by reversing known currents in the primary of an iron-free mutual inductance the secondary of which is in the galvanometer circuit. The current in one of the magnetising coils may be varied suddenly between any two values, positive or negative, by the

use of rheostats and switches; and by switching current from the idle battery (connected to the inductance) into the other magnetising coil, a third current value is obtained. In determining hysteresis loops, two current values are fixed at the ends of the loop, and the third is varied to cover the intervening range. The usefulness of the set is further extended by connecting one magnetising coil to a vacuum tube oscillator circuit for a.c. measurements. A normal magnetising curve and hysteresis loop are given for permalloy tape containing 78·5 Ni and 21·5 Fe. The tape is saturated in a field about 1 gauss, the induction being about 8000. For the loop, $B_{rem.}$ is about 6600 and H_c about 0·05. Weights can be applied to test the effect of tension on magnetisation, as it had been found that local strains in tape coils greatly altered the magnetic properties of the coils. G. E. A.

2840. *Ferromagnetic Constants for Weak Alternating Fields.* **H. Jordan.** (Elek. Nachrichtentechn. 1. 1. pp. 7–29, 1924.)—The paper is in two parts. In the first part, distinction is made between hysteresis and after-effect, the latter being understood to include processes coming under Wiechert's theory (1893). It is assumed that with the application of small forces, pure after-effect, in the sense of the theory, alone enters, but that with increased forces hysteresis also is added. In the second part, with these assumptions, the laws of ferromagnetism are mathematically established, and the impedance of a ring magnet is determined in terms of the frequency and of the amplitude of the current flowing through the coil. The increase of permeability with current is of straight-line form, and the iron losses are expressed in terms of the "loss resistance" r, loss measure r/L, or loss angle $r/\omega L$. The experimental disposition included a modified Wheatstone bridge in which the ring magnet is balanced against a resistance and inductance in series. After balancing for continuous current, the variable arm requires an additional resistance r when a.c. is applied to the bridge, on account of the iron losses in the ring. Losses due to eddy currents, hysteresis, and after-effect are separately expressed, in terms of constants for each. According to Rayleigh, a general relation should exist between the increase of permeability and the hysteresis losses. Some experimental results are given which show the required straight-line increase of hysteresis loss with field strength, and also its relation to the increase of permeability. The after-effect losses in steel wire and in a core of compressed iron powder are very marked. G. E. A.

RADIOGRAPHY AND ELECTRO-PHYSIOLOGY.

2841. *Clinical X-Ray Balance Radiometer.* **L. H. Clark.** (Brit. J. of Radiology, 20. pp. 118–123; Disc., 124, July, 1924.)—The author has applied the principle of Rutherford and Chadwick's γ-ray balance (used in comparing quantities of radium with standards) to the measurement of X-rays. A shadow of the gold leaf of an electroscope is projected on a scale which can be observed from a distance. The instrument promises to be of considerable value in X-ray therapy. A. B. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2842. *Adsorption and Kataphoresis.* **K. v. d. Grinten.** (Comptes Rendus, 178. pp. 2083–2085, June 16, 1924.)—The author places a small glass trough on the stage of an ultramicroscope at the ends of which are fixed platinum foil electrodes charged to 10 volts. The trough is filled with a suspension in water of the same glass prepared by pulverising the glass in an agate mortar; the suspension keeps for weeks. The direction of the migration of the particles is towards the positive pole in the middle portion of the trough and towards the negative pole close to the walls. When the trough is very shallow (0·18 mm. between object glass and cover glass) the velocity in the middle is 9 μ per second. As the thickness increases to 0·5 mm., the velocity decreases to 6 μ and remains constant with greater thickness (up to 1·6 mm.). Along the wall the velocity is 3μ. The velocity measured is the difference between the electro-osmotic and the kataphoretic migration, and according to Helmholtz and Hückel the velocity of a particle relative to the liquid is two-thirds that of the velocity which the particle would have along a wall of the same substance as the particle. The velocity decreases and its sense may be reversed when an electrolyte is added to the suspension the kation of which is absorbed by particles. At low concentration of the electrolyte the adsorption is very rapid; the rate diminishes as the concentration increases. Using crystal violet as the electrolyte the author observed velocities of + 5·6, + 2·6, − 0·72, − 3·0, and − 5·37 μ per second with concentrations of 1/200,000, 1/50,000, 1/20,000, 1/10,000, and 1/2000 gramme-molecule per litre. Similar experiments were made with colloidal selenium and other colloids. H. B.

2843. *The Adsorption of Polonium by Colloids.* **J. H. Brennen.** (Comptes Rendus, 179. pp. 161–163, July 21, 1924.)—The colloid was precipitated by means of electrolytes, and the precipitate filtered with filter paper with very fine pores, such as that used for barium sulphate. The amount of polonium separated with the precipitate, as compared with that left in the liquid, depends on the time, A, during which the polonium remains in contact with the colloid before precipitation, and on the time, B, during which the precipitate is allowed to settle before filtration. Making B as short as possible, the percentage of polonium carried down with the precipitate increases during the first minutes of A, and reaches a maximum in 20 or 30 minutes; it is supposed that this is due to diffusion of polonium into the interior of the colloidal particles. If A is as short as possible, not more than a minute, the percentage in the precipitate increases with B, and reaches a maximum which, within the limits of experimental accuracy, is the same as the previous one. If the colloid is first precipitated and the polonium is added afterwards, the adsorbed polonium increases rapidly, and after half an hour the same maximum is reached as before. Very small quantities of colloidal silver or ferric hydroxide are able to carry down almost the whole of the polonium. H. N. A.

2844. *Adsorption.* **J. Frenkel.** (Zeits. f. Physik, 26. 2. pp. 117–138, 1924.)—When gas atoms or molecules of a gas stream impinge on

the surface of a solid, they are in no way reflected but condense, and after a certain time they re-evaporate. The quantitative development of this idea leads to the following results: The time during which an atom remains adsorbed is $\tau = \tau_0 \cdot \epsilon^{u_0/kT}$, where τ_0 is the period of oscillation (at right angles to the surface) past the position of equilibrium, u_0 is the work of release, and T the absolute temperature. Let ν be the number of atoms impinging per second and n the number of atoms adsorbed; then n/τ will be the number of atoms evaporating per second; and if ν be not too great we have $\nu = n/\tau$ and n remains constant. If the affinity of the adsorbed atoms for one another be greater than for the particles of the adsorbing substance, then when $\nu \geq \nu_k$ or $T \leq T_k$ precipitation of the atoms takes place, principally in the form of doublets, later of higher complexes. T_k corresponds to Knudsen's "critical reflection-temperature." If the affinity of the adsorbed atoms for one another be less than for the particles of the adsorbing substance, then, at temperatures not too high, a compact monomolecular layer is formed on the surface. In the same way it is possible to treat sublimation of solids and particularly their dissociation, which has to be regarded as a preliminary to the process of fusion. A. D.

2845. *Absorption of Lithium Vapour.* **A. L. Narayan** and **D. Gunnayya.** (Roy. Soc., Proc. 106. pp. 51–54, July 1, 1924.)—Channelled absorption spectra have been obtained on both sides of the first line of the principal series, and also a fine line absorption spectrum immediately on each side of the main line.

The lithium was heated up to as high as 1200° C. in a glazed porcelain tube about 50 cm. long and 1 inch in diameter, under reduced pressure. The width of the lithium red line at the maximum temperature used was about 75 A. The wave-lengths of the more prominent bands have been tabulated. A. C. M.

2846. *Absorption Spectra of Vanadium, Titanium, and Scandium.* **H. Gieseler** and **W. Grotrian.** (Zeits. f. Physik, 25. 4–6. pp. 342–366, 1924.)—Absorption lines of these elements have been recorded using a furnace of King's type. By making use of the regularities already known in the arc spectra of these metals, the lines have been thrown into a series scheme.

For vanadium, the lowest level is the F level in the system of quartets. The normal state is given by the term F. It is therefore concluded that the last-bound electron circulates in an orbit of azimuthal quantum number 4.

In titanium the greatest term values correspond to the F level of the triplet system. The normal state of the atom is given by the F_2 term. So in this atom also the last-bound electron circulates in a path of azimuthal quantum number 4.

In scandium the lowest level corresponds to a doublet system level with a separation of 168·5 cm. The authors believe this to be a D-term, in opposition to Catalán, who writes of it as a P-term. A definite conclusion is not yet possible on account of lack of Zeeman-effect data. A. C. M.

2847. *Adsorption from the Gas Phase at a Liquid-gas Interface. Part II.* **T. Iredale.** (Phil. Mag. 48. pp. 177–193, July, 1924.)—In a

previous paper [see Abstract 2042 (1923)] the author described a "drop-symmetry" surface-tension method of determining the amount of adsorption of some organic vapours by mercury. The vapour dealt with was that of methyl acetate. The present experiments show that with vapours of water and benzene similar phenomena are observed, namely that the surface tension decreases as the vapour pressure is increased, but that when the vapour is saturated variable results are obtained. In extreme cases, where the water was actually condensed on the mercury surface, the surface tension fell to a very low value, corresponding to that found for the mercury-water interface. The values of Γ (the surface excess of adsorbed vapour) from the Gibbs equation $\Gamma = -\rho d\sigma/dp$, at the saturation-point, were found to be, for water, $1{\cdot}8 \times 10^{-8}$, and for benzene $6{\cdot}2 \times 10^{-8}$ gram. per sq. cm., being somewhat less than that required for a monomolecular film. Experiments have also been carried out by the author in an attempt to clear up some discrepancies in the literature dealing with the measurement of the surface tension of mercury in a vacuum. It appears possible that the adsorption of water-vapour from the glass of the apparatus is responsible for the anomalies that have been observed. This matter is being further investigated. T. B.

2848. *Adsorption Forces and their Electrical Nature.* **B. Iliin.** (Phil. Mag. 48. pp. 193–200, July, 1924.)—Adsorption is considered to be originated by electrostatic forces, and an expression is derived connecting adsorption capacity $\underset{\sim}{C}$ and the dielectric constant ϵ of the absorbed gas which receives support from experimental data. The heat of adsorption Q is defined as the difference between the external energy of the adsorption field of the adsorbent in a vacuum and in the given gas, an expression relating to the heat of absorption and the dielectric constant of the gas being developed which is confirmed by experimental observations. It is shown that there is a definite parallelism between the changes in $\log \underset{\sim}{C}$, Q, $\frac{\epsilon - 1}{\epsilon}$ and the attraction constant of van der Waals from one gas to another. B. W. C.

2849. *A Correspondence Principle for Absorption.* **J. H. van Vleck.** (Optical Soc. of America, J. and Rev. Sci. Inst. 9. pp. 27–30, July, 1924.) —The basis for the correspondence principle for intensities so successfully developed and applied by Bohr, Kramers, and others is briefly described, it being pointed out that the considerations employed relate primarily to emission in the absence of a radiation field, while no attempt is ordinarily made thoroughly to reconcile the quantum theory terms $B^s_r\rho(\nu_{rs})$ and $B^r_s\rho(\nu_{rs})$ with the classical mechanism of absorption. The author now gives a computation on the basis of classical mechanics of the rate of absorption of energy by an arbitrary multiple periodic orbit in a field of radiation. This for a linear oscillator or rotator reduces to the values derived by Planck and Fokker, but proves to be quite different even at long wave-lengths from the quantum theory expression $h\nu_{rs}B^r_s\rho(\nu_{rs})$ for the average rate of absorption of energy by an orbit, provided B^r_s is determined by $B^r_s = B^s_r = A^s_r C^3/8\pi h\nu^3_{rs}$ and $A^s_r = (2\pi)^4(1/3c^3)c^2\nu^2_{rs}A^2_{\tau_1,\tau_2,\tau_3}h^{-1}$, where $A^2_{\tau_1,\tau_2,\tau_3}$ is $A^{(x)2}_{\tau_1,\tau_2,\tau_3} + A^{(y)2}_{\tau_1,\tau_2,\tau_3}$

$+ A^{(z)2}_{\tau_1, \tau_2, \tau_3}$ evaluated for an orbit having the same size and shape as the stationary state r. As suggested in part to the author by Breit, the solution for this difficulty is that the classical absorption must be compared, not with the true rate of absorption in the quantum theory, but with what he terms the differential rate of absorption, *viz.* $h\nu_{rs}B^r_s\rho(\nu_{rs}) - h\nu_{st}B^t\rho(\nu_{st})$. The states r, s, and t are so chosen that if the quantum numbers of the state s be denoted by n_1, n_2, n_3, then those for the state r are $n_1 + \tau_1$, $n_2 + \tau_2$, $n_3 + \tau_3$, while those for the state t must be $n_1 - \tau_1$, $n_2 - \tau_2$, $n_3 - \tau_3$. ν_{rs} and ν_{st} are in general unequal, but approach each other asymptotically at long wave-lengths, *i.e.* starting with a given orbit of very large quantum numbers there is in Einstein's terminology both a positive and a negative "*Einstrahlung*" of nearly the same frequency, and it is the difference of the two which is to be compared to the classical absorption. This is termed the correspondence principle for absorption. The causes for the asymptotic connection are then examined. H. H. Ho.

2850. *The Use of the Coherer to Investigate Adsorption Films.* **W. G. Palmer.** (Roy. Soc., Proc. 106. pp. 55–68, July 1, 1924.)—Notwithstanding the former widespread use of the coherer or loose-contact detector of electric waves, and the numerous researches on its mode of action, no systematic investigation appears to have been undertaken to ascertain the effect on the detector of the gas surrounding the contact. Branly and others suggested that the cohering effect under electric stress across the contact might be due to the dispersion of a badly conducting film originally lying between the metal surfaces at the point of contact. This hypothesis appears confirmed by the present author's results, which indicate not only a highly specific effect for each gas, but an effect in agreement with the known phenomena of adsorption of gases at solid surfaces. The theory of Eccles, founded upon the thermoelectric properties of the metals in contact, and depending upon temperature changes at the point of contact, seems to be untenable when it is found that cohering action can certainly occur with a frequency of 10^6 times a second [see Abstract 1322 (1920)]. Contacts have now been investigated between fine tungsten filaments taken from an old lamp, platinum filaments, and carbon-tungsten surfaces. The former material is very suitable, since its surface can be cleaned by heating to a high temperature, while it must have been exceptionally well glowed-out. Guthe and Trowbridge indicated that whatever the mechanism of coherence of a loose-contact under electric stress may be, metallic contact ensues after it has taken place. The author has found that the cohered junction would carry a current of a few milliampères with very little resistance for an indefinite time, until the film of condensed gas was again allowed to intrude by tapping the apparatus and so causing the filaments to separate momentarily. This is proof that the current obtainable after cohering is not due to ionisation, and in no case did the voltage impressed across the contact attain the known ionisation potentials of the gases used. Full apparatus and procedure details with data are included, the gases used being nitrogen, oxygen, carbon monoxide, nitrous oxide, nitric oxide, ammonia, ethylene, sulphur dioxide, water, carbon dioxide, ethane, and acetylene. From the critical voltage required to remove the film and bring about metallic contact, the energy of desorption of the gas film is calculated, although assumptions have to

be made that are not readily amenable to experimental test. It is suggested that this method now employed, though indirect, has two important advantages over direct calorimetric determinations upon finely divided materials: (1) Production of a clean filament surface by vigorous glowing; (2) distinction between heat of solution and true heat of adsorption, since gases dissolved in the adsorbent can play no part in increasing the electric resistance at the contact. The latent heat of evaporation of the gas film as calculated is in general of the same order of magnitude as the latent heat of evaporation of the liquefied gas at its boiling-point, and it is therefore tempting to regard adsorption as brought about by agencies similar in nature to those operating in ordinary liquefaction. There would then arise the difficulty of accounting first for a simple process of condensation that occurs at temperatures so far above the boiling-point of the gas, and even in some cases above the critical temperature; and secondly, for the fact that some gases—*e.g.* nitrogen, carbon dioxide and nitrous oxide—are desorbed from tungsten, etc., with practically zero latent heat, in spite of the fact that two of these gases have high critical temperatures. If the adsorption were chemical in nature, the inactive gases, nitrogen, carbon dioxide, and nitrous oxide should be held very loosely to the adsorbing surface. The very large values of the heats of desorption of aged films of oxygen, carbon monoxide, and water on tungsten are comparable with the heat liberated in vigorous chemical action which would be expected on a chemical basis. In some cases it seems that close contact with the metal is able in a short time to open out the electric parts of the adhering molecules and form a more firmly attached film. The values of the heat of desorption of hydrogen, nitric oxide, and sulphur dioxide are practically the same for tungsten and platinum surfaces, although the latter cannot open up carbon monoxide or oxygen in the same way as the more electropositive tungsten. It is suggested that the known sorption of carbon dioxide by carbon is entirely due to solution of the gas. H. H. Ho.

2851. *Electrolytic Corrosion in a Water Gas-holder.* **F. H. Rhodes** and **E. B. Johnson.** (Indust. and Engin. Chem. 16. p. 575, June, 1924.)—The attention of the authors was called recently to the following instance of electrolytic corrosion, which was interesting and rather unusual, for the electrolysis was brought about by having a single piece of metal in contact with two solutions of different oxidising power rather than by having two different metals in contact with each other and with a single solution. In the outer tank of a gas-holder severe corrosion developed throughout a horizontal zone extending from about 4 in. to about 3 ft. below the level of the sealing water. Throughout this entire zone the steel was badly attacked, and many holes, some of them as large as 0·25 in. in diameter, were eaten through the plates. There was no evidence of attack at or just below the level of the sealing water nor in the lower part of the tank. The particular holder in which this corrosion occurred was a relief gas-holder which received raw gas directly from the water-gas machines. At the same plant another holder, which was used for storing a mixture of purified water-gas and purified coal-gas, showed no evidence of localised attack. It appeared very probable therefore that the corrosion was due either directly or indirectly to the presence of some impurity (possibly hydrogen sulphide) in the raw gas. Samples of the sealing water from near the surface and from about

20 ft. below the surface were analysed for total sulphur. The results were as follows :—

Sulphur in water from top .....0·0055 grammes per litre.
Sulphur in water from 20 ft. below surface ....0·0109 grammes per litre.

That the corrosion was not due to the simple rusting of the iron by oxygen dissolved in the water is indicated by the fact that the attack was more severe below the water level than at the surface of the water where the concentration of dissolved oxygen was greatest. That the corrosion was not due to the simple chemical action of the dissolved hydrogen sulphide on the iron is shown by the fact that the attack was confined to a narrow zone near the top of the holder, although the water near the bottom of the holder was in more direct contact with the gas and should contain a higher concentration of dissolved hydrogen sulphide. The observed facts may be explained by the assumption that the corrosion was electrolytic in character, the required difference of potential for the electrolysis being produced by an oxidation-reduction cell. The water at the top of the holder contained some dissolved oxygen, and the iron shell in contact with this oxidising solution formed the kathode. The water at some distance below the surface contained dissolved hydrogen sulphide and possibly other active reducing substances, so that the iron shell in contact with this reducing solution formed the anode. The electrolysis therefore would be confined to the region near the zone in which the transition from the oxidising solution to the reducing solution took place ; and most of the corrosion would occur immediately below this transition zone. This electrolytic theory therefore explains the fact that the corrosion is confined to a narrow band somewhat below the water level. The theory also accounts for the large amount of iron oxide in the scale.

In order to confirm the theory that an oxidation-reduction cell was established by the metal in contact with the upper and lower layers of water in the holder, a cell was constructed in which one element was an iron wire in contact with a portion of the sealing water taken from the lower part of the holder, while the other element was a similar wire in contact with some of the water from the surface. The electromotive force of this cell, as measured by a potentiometer, was 0·02 volt, the wire in the water from the top of the holder being the kathode. The wire in the reducing solution was very appreciably corroded, while the wire in the surface-water remained bright. J. B. C. K.

2852. *Surface Tension of Colloidal Solutions and Dimensions of Certain Organic Molecules.* **P. L. du Nöuy.** (Phil. Mag. 48. pp. 264–277, Aug., 1924.)—By means of an apparatus depending on the pull on a ring, investigations have been made on the spontaneous fall in the surface tension of all colloidal solutions. This fall increases with the dilution and exhibits a maximum at a given concentration, usually between 10^{-4} and 10^{-5}. For colloids such as blood serum and albumen, which have not been regarded as having a powerful action on the surface tension of water, the fall may amount to 20 dynes per cm. At high concentrations, certain colloids, such as saponin, may show even a slight increase in surface tension.

The surface tension of these colloidal solutions rises when the liquids are stirred. The existence of an accurate criterion of the existence of a

mono-layer at a known concentration renders possible the calculation of the thickness of such a layer. This criterion—the minimum value—does not always coincide with the maximum fall. With pure soluble substances, such as albumens, etc., it gives the length of the molecule, and when the molecular weight is known, the cross-section of the molecule can be calculated. The length of the molecule of sodium oleate is found to be $12{\cdot}3 \times 10^{-8}$ cm. and its width $6{\cdot}8 \times 10^{-8}$ cm., whereas the length is $43{\cdot}3 \times 10^{-8}$ cm. for serum albumen and $52{\cdot}8 \times 10^{-8}$ cm. for egg albumen.

The crystallisation of sodium chloride or other salt solution is affected by the presence of even one-millionth part of most colloids, which prevents the formation of large crystals on the bottom of a watch-glass containing the solution. The molecules and ions are adsorbed on the colloidal micellæ and carried up to the surface layer, and, as evaporation proceeds, the colloidal particles with their adsorbed sodium chloride are deposited on the glass in concentric beaches; with certain concentrations of the colloids, periodic, concentric rings are formed.

Evaporation of serum solutions in watch-glasses is slower at a dilution of 10^{-4} than at any other concentration, this being regarded as the result of the formation of a monomolecular, oriented layer. When sodium oleate or any surface-active colloid is added to a more inert colloidal solution, such as one of pure serum, the surface tension falls in value considerably, then immediately rises, and may reach its initial value in seven minutes. T. H. P.

2853. *The Theory of Osmotic Pressure, Membrane-Potential and the Flocculation of Colloids. Investigations on Colloidal Chromic Hydroxide.* **N. Bjerrum.** (Zeits. phys. Chem. 110. pp. 656–684, 1924.)—In continuation of earlier work on basic chromium compounds, an investigation is made of the properties of colloidal chromium hydroxide, which is prepared by acting on chromic nitrate with dilute sodium hydroxide and dialysing the oxide by means of a collodion membrane. The oxide thus produced is of great stability, and can be kept in contact with dilute acid solutions for a year without essential change of its properties. Measurements of osmotic pressure are made of samples of this hydroxide contained in a collodion cell when at various concentrations and in presence of different electrolytes such as hydrochloric acid. It is verified that the osmotic pressure is determined by the sum of two factors, P_1 the pressure of the colloid itself and P_2 that produced by the difference in concentration of the dialysed ions, when in equilibrium, on the two sides of the membrane in accordance with the Donnan law. It is found experimentally in accordance with this law that the following relation is followed in the case of monovalent ions :—

$$P_1 = RT[Cr]/n \text{ and } P_2 = RT(q/2)^2[Cr]^2/c$$

where [Cr] is the concentration of chromium in grm. atoms per litre, n the mean number of Cr atoms in the colloid particle, q the mean number of free positive charges on the colloid per Cr atom, c the ionic concentration of the electrolyte. From the osmotic measurements it is calculated that the colloid particles of the chromic hydroxide contain on an average about 1000 Cr atoms and 30 free charges.

Measurements of potential are made by hydrogen and calomel electrodes connecting with the two solutions. The relation between

inner and outer ionic concentration and the compensating membrane potential which is required by Donnan's theory is found to be followed. According to this, $I_a/I_i = (e^{\epsilon_M F/RT})^n$ where ϵ_M is the difference of potential across the membrane when osmotic equilibrium is reached, I_a, I_i the ionic activities or concentrations of the respective solutions, and n the valency of the ion. The values of I_a/I_i are determined by measuring the concentration of both H and Cl ions by hydrogen and calomel electrodes respectively, and in the former case also by a chemical method. The conclusions reached are in agreement with earlier work by Loeb on protein solutions. Values for the membrane potential calculated from the formula $P_2 = RTc(\epsilon_M F/RT)^2$ which is deduced from the theory are lower than the observed. The discrepancy is attributed to the non-validity of the assumption that the activity of the ions is identical with their osmotic effect on account of the adsorption of anions (Cl′) by the colloid particles. From the amount of the absorbed ions as determined by chemical analysis and potential measurements and the free charges, the average total charge on the colloid particles is estimated to be 240 ions. The total charge on the colloid particle per grm. atom of Cr varies from 0·24 in presence of 0·01 HCl to 0·17 with 0·001 HCl. This fall with diminishing acid content is attributed to the effect of hydrolysis. A relation which has not yet been determined exists between the amount of absorbed anion, the free charge of the colloid, and the anion activity.

In flocculation with polyvalent ions, the precipitation zone is found to be narrow, well-defined, and independent of time. The amount of ferrocyanide ions necessary for complete flocculation corresponds closely to the total charge of the colloid. In the case of bivalent sulphate ions, rather more is required. [See also Abstract 348 (1907).] J. N. P.

2854. *Electrometric Study of the Hydrolysis of Salts.* **P. Job.** (Comptes Rendus, 179. pp. 49–52, July 7, 1924.)—The course followed by the hydrolysis of a salt of a weak acid or of a weak base may be determined by measurements of the hydrogen-ion concentration. By this means it is found that the action of hydrochloric acid on a pyrophosphate in 0·001 N-concentration takes place in three phases: (1) The addition of 1 mol. of acid, $H^\bullet + P_4O_7^{''''} \rightarrow HP_4O_7^{'''}$, the dissociation constant then being of the order $3\cdot10^{-9}$; (2) $HP_4O_7^{'''} + H^\bullet \rightarrow H_2P_4O_7^{''}$ (k = about 10^{-6}); (3) when all the pyrophosphate has been transformed into disodium salt, it behaves as a neutral salt, the last two acidities being thus strong acidities.

In the case of borax, the curve obtained may be interpreted by assuming that the ion B_4O_7 exists only in the solution in very small quantity; that it is transformed under the influence of water into boric acid and the metaboric ion, BO_2^1 or $H_2BO_3^1$, and that it is the hydrolysis of a mixture of boric acid and metaborate which is observed. According to this hypothesis, the dissociation constant of boric acid is of the order 10^{-9}.

The hydrolysis of ammonium salts and alkali acetates, in solutions of normality between about 0·001 and 0·03 and of hydrogen-ion concentration between 10^{-7} and 10^{-3} for acetates or 10^{-7} and $3\cdot10^{-12}$ for ammonium salts, conforms to the ionic theory. T. H. P.

2855. *Effect of Hydrogen-Ion Concentration on the Submerged Corrosion of Steel.* **W. G. Whitman, R. P. Russell** and **V. J. Altieri.** (Indust.

and Engin. Chem. 16. pp. 665–670, July, 1924.)—The main factors in the corrosion of steel submerged in natural waters, dilute alkalies, and dilute acids are the protectiveness of films of corrosion products and the rate of oxygen diffusion.

The degree of film protection is determined largely by the p_H of the solution adjacent to the metal, since this affects the solubility of ferrous hydroxide and hence the physical condition of the precipitated film. In the alkaline region increased p_H renders the liquid next to the metal more alkaline and causes the formation of a more protective film, although the initial rate of corrosion is as great as the rate in natural waters. This film requires some time to develop its full protectiveness, and it is not readily destroyed when the alkalinity of the solution is reduced. The determining factor is thus increased film protection rather than insufficient hydrogen-ion concentration. The results of various observers, who observed a maximum rate of corrosion at a "critical" alkalinity, are invalidated by failure to protect the solution from carbon dioxide in the atmosphere.

Throughout the whole region of natural waters the film protection of a given water is constant, since the p_H of the solution next to the metal is maintained at the constant value 9·5 by the solubility of ferrous hydroxide, the corrosion being determined by the rate of diffusion of dissolved oxygen to the corroding solid.

On the acid side of the natural water region evolution of hydrogen starts when the alkalinity of the liquid next to the metal is neutralised by the acid in the main solution. This point depends principally on (1) the rate of mixing of main solution and surface liquid, (2) the total acidity in the main solution, and (3) the rate of production of alkali in the surface liquid by the process of corrosion. On account of (2) a weak acid will induce evolution of hydrogen at a lower hydrogen-ion concentration than is required with a strong acid, and on account of (3) decrease in oxygen concentration, which will decrease corrosion and production of hydroxyl ions, will permit readier neutralisation, and hydrogen will be evolved at lower acidities.

The rate of oxygen reaction in the acid region is greatly increased by the facts that evolution of gas causes turbulence in the liquid adjacent to the metal surface, and thus increases the rate of oxygen diffusion, and that the protective film is absent. [See Abstract 2615 (1924).] T. H. P.

2856. *Representation of the Periodic Sytem.* **W. Palmaer.** (Zeits. phys. Chem. 110. pp. 685–704, 1924.)—By means of the so-called quadratic rule, according to which hydrogen is placed at the head of the alkali metals, the number of elements in the different periods is fixed and the arrangement of the periodic system facilitated. Atoms with $2n^2(n = 1, 2, 3, \text{or } 4)$, or if $n = 2, 3, \text{or } 4$, also with double as many electrons must form extremely stable configurations (rare gases), and the paths of the electrons are distributed on surfaces.

The normal potentials of the elements—which may be taken as a measure of the chemical affinity—exhibit pronounced periodicity, which is simple in the first three periods and double in the two large periods; hence multiple periodicity is to be expected in the very large periods. The fact that, at the positions of the rare gases, the curve is at least apparently discontinuous supports the view that the rare gases limit the different periods.

On these foundations is constructed a representation of the periodic system, in which the essential novelty is the distribution of all the rare earth metals in the principal sub-groups of groups III and IV. The data necessary for testing the accuracy of this view are as yet incomplete.
T. H. P.

2857. *Studies in Heterogeneous Equilibria. Part III. A Kinetic Theory of Reversible Oxidation Potentials at Inert Electrodes.* **J. A. V. Butler.** (Faraday Soc., Trans. 19. pp. 734–739, March, 1924.)—A kinetic theory of reversible oxidation potentials at inert electrodes is developed. The probability is indicated that when an electrode is in contact with a solution, the ions in the immediate vicinity of the surface become adsorbed to some extent. The case is considered of two ions, M_I and M_{II}, differing only in their state of oxidation and carrying n_1 and n_{II} positive charges respectively. The process may be represented by the equation $M_I + \epsilon = M_{II}$, where ϵ represents an electron. Through the agency of the free electrons of the metal electrode, M_{II} will tend to lose its extra electron, while M_I will tend to gain an electron. If the rates of these two changes are initially unequal the metal surface will be left with a charge which will accumulate until the processes occur at equal rates.

Expressions are derived to evaluate the work done by the following changes: (1) The displacement of an electron to the "balance-point" against the surface attractive forces of the metal, or ϕ_1; (2) the additional electrical work, E_sF, performed on account of the existence of a p.d. E_s at the surface; (3) the removal of an electron from its stable position or orbit in M_{II} to the "balance-point" involving the work ϕ_2; (4) the displacement of the molecules or ions from the surface to the balance-point and from the interior to the balance-point; (5) the energies of hydration of the ions M_I and M_{II}, denoted by H_{M_I} and $H_{M_{II}}$ respectively. The final expression for the normal oxidation potential reduces to the following:—

$$E_0 = \frac{\phi_2 - \phi_1}{F} + \frac{RT}{F} \log_e \frac{k_1}{k_2} - \frac{H_{M_I} - H_{M_{II}}}{F}$$

Further $\phi_2 - \phi_1 = (V - \phi_0)\ F$ where V is the ionisation potential corresponding to the removal of an electron from M_{II} in solution, and ϕ_0 is the thermionic work function of the metal. The oxidation potential is thus determined by (1) the ionisation potential corresponding to the loss of an electron by the reduced molecule; (2) the difference in the energies of hydration of the two substances concerned; (3) the thermionic work function of the metal; (4) the values of k_1 and k_2, which are the constants in the exponential relation, giving the rate at which the processes $M_I + \epsilon \rightarrow M_{II}$ and $M_{II} \rightarrow M_I + \epsilon$ occur. Since the quantities (1) and (2) cannot be evaluated, a direct comparison between observed and calculated values is not possible. A further case dealt with is that of the p.d. of a metal in contact with a solution containing its ions in different stages of oxidation. [See Abstracts 2625 and 2626 (1924).] J. N. P.

2858. *Molecular Attraction and Combination.* **O. Maass.** (Frank. Inst., J. 198. pp. 145–159, Aug., 1924.)—Direct evidence of molecular attraction between molecules of different gases is afforded by the change in pressure when they are mixed. For permanent gases the effect is

small, but for mixtures such as methyl ether and a halogen hydride the change in pressure may amount to 4 cm. at normal pressure. When the inter-molecular attraction becomes very great there is a tendency to form molecular compounds, and the existence of these is often confirmed by freezing-point curves. It is suggested that for many reactions to take place the molecules must be moving slowly, since then the attraction between them will tend to orientate them favourably. A. Wh.

2859. *The Nature of Non-Ionised Acids. Correction.* **A. Hantzsch.** (Zeits. Elektrochem. 30. p. 397, Aug., 1924.)—In a first paper [Abstract 2329 (1923)], the author had stated that solid oxalic acid (a pseudo-acid) was indifferent towards his azo-indicator, whilst in a second paper [*ibid.* 30. p. 206, 1924] the acid was said to colour the indicator yellow, not red. The apparent contradiction is due to the use of two different indicators of the same type, dimethylamino-azobenzene and amino-azobenzene. H. B.

2860. *Non-luminous Oxidation of Phosphorus in an Oxygen Atmosphere.* **(Lord) Rayleigh.** (Roy. Soc., Proc. 106. pp. 1–8, July 1, 1924.)—The views on phosphorescent combustion of phosphorus developed in former papers [Abstract 335 (1924)] require that phosphorus vapour, when apparently inactive in an atmosphere of oxygen, should in reality be combining with it at isolated centres, though the action fails to spread. It is now shown that slow oxidation does, in fact, take place under these conditions. By suitable manipulation, either this action or the ordinary phosphorescent combustion may be caused to occur at one given pressure and external temperature. The rate of oxygen absorption is widely different in the two cases, so that there can be no doubt that they are really distinct. Stringent photographic tests show that luminosity does not accompany the slow action. It is found that, with a given area of phosphorus surface, the rate of action is enormously increased by allowing a large oxygen space round it. This and other experiments show that the action occurs in the volume of the gas space, and therefore between oxygen and phosphorus vapour. A. W.

2861. *Atomic Dimensions and Chemical Reactivity.* **H. L. Riley.** (Phil. Mag. 48. pp. 126–128, July, 1924.)—If the hydrogen molecule be supposed to be approximately spherical, the diameter will be $2 \cdot 5 \cdot 10$ cm. This is assumed to give an approximate value of the radius of the orbit of the binding electrons, and it is pointed out that those elements which have an atomic diameter less than this form hydrides with the evolution of energy, and those with greater radius form hydrides with absorption of energy. A table for fifteen elements is given. It is suggested that the only chance for an atom to upset the equilibrium of the hydrogen molecule, itself a very stable structure, is actually to penetrate the electron ring. This can easily occur when the diameter of the reacting atom is less than that of the ring, but not when it is greater. Reference is also made to the smooth relation indicated when the free energy of the halogen acids is plotted against the reciprocal of the atomic diameter.
A. Wh.

2862. *The Quantum Sensibility of the Uranyloxalate Photolysis.* **P. F. Büchi.** (Zeits. phys. Chem. 111. pp. 269–314, Aug. 5, 1924.)—

Having reviewed the previous work on the photolysis of uranyl oxalate, which yields formic acid, carbon dioxide, carbon monoxide and uranous salt (the formation of which may cause turbidity), the author describes experiments made by exposing to the rays of a half-watt lamp, with or without colour filters, solutions of uranyl oxalate and of mixtures of uranyl nitrate, uranyl sulphate, or acetate and oxalic acid. The concentration of the uranyl salt was always low, 1/60 molar on the average, in order to avoid complication by the turbidity arising during the reaction. The reaction was watched by analysis of the liquid phases; the control of the gaseous phases was not suitable. It is found in confirmation of previous researches that the photolysis depends upon the uranyl oxalate, whether present as such or in complexes with the other salts, and is due to the decomposition of undissociated $UO_2C_2O_4$ and of its ions $[UO_2(C_2O_4)_2]''$. The presence of oxalic acid is of no importance for the rate of decomposition. Owing to the high stability of the complexes formed, the photolysis is not influenced either by additions of oxygen, hydrochloric acid, sulphuric acid, and formic acid, unless they disturb the complexes mentioned; but the acidity does influence the formation of formic acid and of the uranous salt. In accordance with Einstein's law 1 molecule of oxalic acid is decomposed per light quantum adsorbed. In the case of uranyl formate dissolved in sulphuric acid, $0{\cdot}7 \pm 0{\cdot}2$ molecule of uranous salt is formed per quantum; this value is said to be in agreement with Hatt's value 0·4 (*ibid.* 92. p. 513, 1917). H. B.

2863. *On the Electrical Explanation of Chemical Forces.* **M. Born.** (Zeits. Elektrochem. 30. pp. 382–386, Aug., 1924. Paper read before the Deut. Bunsen Gesell., Göttingen, 1924.)—This paper assembles together the salient facts in support of the electrical theory of chemical affinity. Kossel's conception of the electrical character of chemical forces is first discussed at length from its two standpoints of electrostatic attraction and ionic formation through acceptance and emission of electrons. Modern atomic theory and atomic constants next receive attention, leading to the electrostatic lattice theory. Nernst's objections to the Kossel theory are then considered and shown to be untenable. It is also established that directed valencies in the ordinary chemical sense find no place in electrical theory, and the mode of reconciliation between the two conceptions is discussed from the energy standpoint in relation to geometrical arrangement. H. H. Ho.

2864. *Chemical Reactions in the Glow Discharge.* **A. Günther-Schulze.** (Zeits. Elektrochem. 30. pp. 386–391, Aug., 1924. Paper read before the Deut. Bunsen Gesell., Göttingen, 1924.)—The normal kathode fall for a number of gas mixtures has been determined, and from the curves obtained conclusions may be drawn as to how and to what extent chemical reactions occur in the glow discharge, also as to which are the primary effective ions in these reactions. It is then possible to detect chemical reactivity in such mixtures as He–O and Ar–O where reaction products cannot be isolated. Experimental details are included with tables of data. H. H. Ho.

2865. *Concentration Cells and Electrolysis of Sodium Ethoxide Solutions.* **M. Shikata.** (Faraday Soc., Trans. 19. pp. 721–728, March, 1924.)—The research was undertaken to investigate the use of the mercury-drop

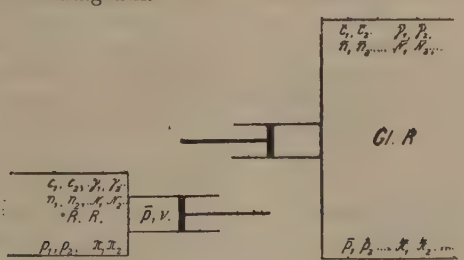
electrode [see Heyrovský, Abstract 1279 (1923)] for the study of the electrolysis of non-aqueous solutions. The ethoxide is prepared by dissolving metallic sodium in pure dry alcohol, the solution being kept in the dark over diluted sodium amalgam and transferred into the cell by means of a current of dry hydrogen. The ethoxide did not evolve hydrogen when standing in contact with the amalgam for several days, and during that time the potential of that amalgam against a mercuric oxide electrode remained steady at 2·0855 volts. The deposition of sodium at the mercury-drop kathode is reversible as in the case of aqueous solutions. But the e.m.f. of the concentration cells indicates a quite abnormally high activity of the sodium ions setting in at a certain concentration, which is accompanied by changes in the conductivity and vapour-pressure, and attributed to diminution of the solvation of the sodium ions. H. B.

2866. *The Calculation of the Work of Chemical Change with Variable Concentration.* **C. Frenzel.** (Zeits. phys. Chem. 110. pp. 547–558, 1924.)—The author takes a reaction represented by

$$n_1a_1 + n_2a_2 + \ldots \rightleftarrows v_1a_2 + v_2a_2 + \ldots$$

The initial state is given by: Initial concentration $c_1c_2 \ldots \gamma_1\gamma_2 \ldots$; initial partial pressure $p_1p_2 \ldots \pi_1\pi_2 \ldots$; number of molecules $N_1N_2 \ldots R_1R_2 \ldots$ In the equilibrium state: Concentration $\bar{c}_1\bar{c}_2 \ldots \bar{\gamma}_1\bar{\gamma}_2$; partial pressure $\bar{p}_1\bar{p}_2 \ldots \bar{\pi}_1\bar{\pi}_2$; number of molecules $\bar{N}_1\bar{N}_2 \ldots \bar{R}_1\bar{R}_2 \ldots$

Let U = constant volume, and for brevity putting $\mu = (c_1 - \bar{c}_1)V/n_1 = (c_2 - \bar{c}_2)V/n_2 = \ldots (\bar{\gamma}_1 - \gamma_1)V/v_1 = \ldots$. If the number of molecules of species a_1 which undergo transformation is n_1, then $\mu = (c_1 - \bar{c}_1)V/n_1 = (N_1 - \bar{N}_1)/n_1 = 1$, etc. The transformation may be visualised by the diagram.



The process is carried out in the following way:—

1. As many molecules a_1 are taken from the space RR by the piston through the semi-permeable membrane as will make the concentration in RR equal to $\bar{c}_1$ and the pressure $\bar{p}_1$. By this means $N_1 - \bar{N}_1$ molecules a_1 leave RR and enter the piston, and the work done is $\int_{p_1}^{\bar{p}_1} p \,.\, dv = N_1RT \log (c_1/\bar{c}_1)$.

2. The $N_1 - \bar{N}_1 = \mu n_1$ molecules a_1 at pressure $\bar{p}_1$ are now incorporated into the space G/R, which requires the expenditure of external work $= -(N_1 - \bar{N}_1)/RT = -\mu n_1 RT$.

3. As many molecules of a_1 are taken from RR at constant pressure π_1

as are necessary to raise the pressure of this component from γ_1 to $\bar{\gamma}_1$. Since $(\bar{\gamma}_1 - \gamma_1)V/v_1 = \mu$, this requires μv_1 molecules, and the work gained is $\mu v_1 RT$.

4. These μv_1 molecules of a_1 are brought to the pressure of those molecules π, π_1 in RR, which requires expenditure of work $\mu v_1 RT \log (\bar{\pi}_1/\pi_1)$.

5. Finally, this quantity is forced by the piston into RR, whereby $R_1 + \mu v_1$ molecules are raised from pressure π_1 to pressure $\bar{\pi}_1$. This requires an expenditure of work equal to $(R_1 + \mu v_1)RT \log (\pi_1/\bar{\pi}_1)$. Extending this to all species of molecules and introducing concentrations, the total work is

$$RT \log \{[c_1^{N_1} c_2^{N_2} \ldots \gamma_1^{R_1} \gamma_2^{R_2}]/[\bar{c}_1^{N_1} \bar{c}_2^{N_2} \ldots \bar{\gamma}_1^{R_1} \bar{\gamma}_2^{R_2} \ldots]\} - \mu RT(\Sigma n - \Sigma v)$$

The author then discusses special cases and compares his results with those of Thiel in the Lehrbuch von Küster and Thiel, vol. 2, Heidelberg, 1923, p. 1427. T. B.

2867. *Electrolysis of Potassium-Sodium Alloys.* **R. Kremann** and **R. G. v. Rehenburg.** (Zeits. phys. Chem. 110. pp. 559–571, 1924.)—With suitable current densities, molten alloys exhibit electrolytic effects, the observed alterations in the concentration being the resultant of the electrolysis and of the diffusion, which acts in the opposite direction. As the current density is increased, the electrolytic effect increases and continually approaches a limiting value. The results now given refer to a potassium-sodium alloy with about 70% of potassium, this being of nearly the eutectic composition and liquid at ordinary temperatures. The electrolysis was carried out in stout capillary tubes of about 1 mm. bore, and at temperatures between 100° and 110°, at which all the possible alloys remain liquid. T. H. P.

2868. *Electrolysis of Fused Salts.* **R. Lorenz.** (Zeits. Elektrochem. 30. pp. 371-375, Aug., 1924. Paper read before the Deut. Bunsen Gesell., Göttingen, 1924.)—General notes on the subject with special regard to the equilibrium between metal and salt in melts. When molar fractions are substituted for concentrations the Nernst-Ogg formula for the e.m.f. can be calculated by Tammann's formula in cases when the one component is present at considerable dilution, *i.e.* for the ends of the equilibrium isothermal. This is found to hold for the differential e.m.f. of the chains $Cd|CdCl_2|Cl_2$ and $Pb|PbCl_2|Cl_2$, as determined by Lorenz, Fraenkel and Silberstein; but the author doubts the implied validity of the law of mass action for the whole of the isothermal. A formula of his own based upon the Duhem-Margules vapour-tension isothermal is found to be applicable only to fused lead and cadmium and their chlorides. The problem can, however, be solved with the aid of van Laar's thermodynamic potentials. H. B.

2869. *Protective Effect on Suspensions of Electrolytes added in Quantities Too Small to Effect Flocculation.* **A. Boutaric** and **(Miss) G. Perreau.** (Comptes Rendus, 179. pp. 46–49, July 7, 1924.)—Flocculation of colloidal solutions of gamboge or mastic by addition of an electrolyte is retarded by previous addition of a small amount of electrolyte. In general such protective action is not observed with arsenic sulphide solutions. If the electrolyte first added is different from that used to effect flocculation, its effect may be either protective or accelerative. T. H. P.

2870. *The Conception and Properties of the Electrical Double Layer and its Relation to Ionic Migration.* **J. W. McBain.** (J. Phys. Chem. 28. pp. 706–714, July, 1924.)—The present state of knowledge of the double layer between liquids and such materials as glass, membranes and colloidal particles is reviewed and the different assumptions which have been put forward in calculating the "contact potential" are discussed. According to Helmholtz the whole of the movement in these systems is due to ordinary viscous flow within the part of the liquid within the double layer. The deductions made by Helmholtz on the thickness of the double layer calculated from the condenser action of electrodes are discussed. The high-contact potentials formerly derived are now found to be much lower, while the thickness of the double layer and the number of charges are much less than the values formerly held. The fundamental assumption in all these previous calculations has been that the charges, or rather the mobile ions, form an effectively complete sheath, shutting off the body of the liquid in the tube from the annular space of the double layer. It is now considered, however, that the mobile ions, instead of being a complete monomolecular sheath, consist of scanty isolated ions, and that nearly all the ions of the adsorbed film are sessile and immovable. These immovable ions may be of opposite kinds, or few, or may form a practically complete adsorbed layer. A sessile ion may be balanced by a charge within the solid or by a mobile ion in the liquid. It is calculated that the mobile ions cover, at any given moment, only a small fraction of 1 per cent. of the surface. The above conception appears to harmonise the existing data, including also those for absolute electrode potentials and for the behaviour of sols, gels, and curds of soap. If this conception is a true interpretation of the existing data, the fundamental assumptions made in all previous mathematical treatment of this subject are invalid. J. N. P.

2871. *A General Formulation of Movement in an Electrical Field: Migration, Electrophoresis and Electroösmosis of Sodium Oleate.* **Mary E. Laing.** (J. Phys. Chem. 28. pp. 673–705, July, 1924.)—A large number of measurements of electrolytic migration are made with sodium oleate solutions, which has the property of being available in the three forms of sol, gel and opaque curd. For this purpose determinations are made during electrolysis of these solutions in tubular vessels of concentration changes in different portions of the vessel. It is established that the phenomena of electrolytic conduction, electroösmosis and electrophoresis are special cases of an identical process of which the essential feature is the relative movement between solvent and carrier. A general formula is derived to express the actual movement relative to the solvent of each constituent of any electrically conducting system, whether homogeneous or heterogeneous, electrolytic, colloidal or involving electrical double layers or diaphragms. This has the form $n_1 = \frac{c_1 m_1 f_1}{\mu}$, where c_1 is the number of chemical equivalents per 1000 grm. of solvent, m_1 the number of chemical equivalents which carry one electrical charge, f_1 the conductivity in reciprocal ohms of one chemical equivalent, and μ the total conductivity or the sum of the concentration of each conducting constituent multiplied by its mobility. The movement of the solvent relative to any conducting constituent is $\frac{m_1 f_1}{\mu}$ kilos. of solvent per faraday of current.

The velocity of electrophoresis and mobility are only identical when m_1 is equal to unity, that is, when there is one electrical charge per chemical equivalent. From this standpoint the only distinction between colloid and crystalloid is the number of chemical equivalents which are associated with one electrical charge. The voltages produced by the streaming of liquid past surfaces or of powders through liquids are related to the mobilities and charges in the same way that such potentials as diffusion potential are related to ionic mobilities. The ionic micelle is a case of an " electrical double layer " where the conductivity of both parts of the layer is operative, and it indicates that the participating ions and surfaces retain an unimpaired electrical conductivity.

The movement of each constituent of soaps in solution relative to the solvent during the passage of the current is unaffected by gelatinisation, and remains the same whether the gel moves as a whole or in parts through the solvent or when the gel is fixed so that the solvent has to move through the gel. The identity of these values for sol and gel affords evidence for the conclusion that the colloidal particles in sol and gel are identical in nature and amount, except that in the gel some of them are arranged possibly in filaments or other loose structure, affording no additional resistance to the passage of the electrical current.

In dilute solution the migration of sodium oleate is that of an electrolyte ; in the more concentrated solutions rather more sodium is moved towards the anode than towards the kathode. In a curd still more movement towards the anode is observed, which may in some cases exceed five equivalents of oleate per 1 faraday of current. Data are derived on the degree of hydration of the constituents of soap in solution.

J. N. P.

! **2872.** *The Mass-Action Law in Ionised Systems.* **W. Wessel.** (Phys. Zeits. 25. pp. 270–277, June 1, 1924.)—In a consideration of the osmotic and activity phenomena of strong electrolytes a simplification in the treatment of the relations which has been made by P. Debye [Abstract 1957 (1924)] is applied by the present author in a wider connection which includes both gases and solutions, and the range of the simplification is further extended. The relations are subjected to detailed mathematical treatment. Account is taken of the ionic density in the distribution of charged particles around an ion. Through the influence of the charge, the concentration of particles with charges of opposite sign to that of the ion will be somewhat increased and that of the particles with the same sign will be diminished. This effect will lead to a diminution of potential of the ion and a lowering of its inner energy, which leads to a modification of the mass-action relation. According to the Boltzmann principle the following relation applies :—

$$n_i(r) = n_i^0 e^{-z_i \epsilon \psi(r)/kT}$$

$\epsilon = 4 \cdot 77 \cdot 10^{-10}$ el. st. C.G.S., $k = 1 \cdot 37 \cdot 10^{-16}$ erg/degree, where $n_i(r)$ is the mean density of the ion of the order i at the point r, $\psi(r)$ is the potential, z_i the number, and $z_i\epsilon$ the charge of the ions, and n_i^0 their density in a charge-free space. It is inferred that for a low degree of ionisation, ionised gases obey the Guldberg-Waage mass-action law when to the energy of formation of the compound is added the electrical energy of the components. Thus the energy of formation U_0/N of a molecule is to be regarded as the work which must be applied to separate completely

the components and bring them to zero potential. It is deduced that the electric energy per molecule is given by the expression :

$$U_{i_e} = -Nz_i^2\epsilon^2\chi/2$$

where N is Avogadro's number and χ is the density of the ionic atmosphere.

The equilibrium constant of the mass-action law K_c is, in its modified form, given by the expression :

$$K_c(T)e^{-v_iU_{i_e}/kT}$$

where v_i is the number of ions of the type i. Debye gives this expression the form $f_aK_c(T)$, where f_a is the activity coefficient, accordingly :

$$lnf_a = -\sum_{i=1}^{s} v_iU_{i_e}/kT$$

whence $RTlnf_a$ represents the " electrical total energy decrement of the process." It is considered preferable to substitute the conception of " activity coefficient " by that of the " inner electrical energy per molecule." J. N. P.

2873. *Dissociation of Acids in Alcohols.* **E. Schreiner.** (Zeits. phys. Chem. 111. pp. 419–430, Aug. 25, 1924.)—Having applied the theory of electrolysis of Bjerrum to the dissociation of aqueous solutions of acids, the author proceeds to an investigation of solutions in ethyl and methyl alcohols. The law of mass-action is found to hold also for strong acids like picric acid, even in the presence of water ; but the activity constants of the ions deduced are too great and do not agree with those calculated from the dielectric constants of alcohol and of water. The data used are the conductivities of H. Goldschmidt and the dissociations in ethyl alcohol of E. Larson (Dissert., Lund). According to Bjerrum, the esterification of weak acids under the catalytic influence of stronger acids would merely depend upon the hydrogen-ion concentration. The relations are not always so simple, however, as the author shows by analysing Goldschmidt's values. For various reasons he assumes that hydrochloric acid is not completely dissociated in alcohol. He is studying the dissociation by electrometric, katalytic, and refractometric methods. H. B.

2874. *The Determination of the Secondary Ionisation Constants of Dibasic Acids.* **T. Paul.** (Zeits. phys. Chem. 110. pp. 417–434, 1924.)—The dissociation equilibrium of dibasic acids and their salts in water is considered, in particular tartaric acid is treated in both practical and theoretical detail. In view of its significance in biological chemistry, it is of great importance to determine the secondary ionisation constant of this acid. A list is given of the methods used and the results obtained by other investigators. The present writer obtains a new value of K_2, using the methods of sugar inversion and electrical conductivity. This value is in good accord with previous work, as is also the value of K_1 determined simultaneously. A. A. D.

2875. *Overvoltage in Electric Reactions.* (Faraday Soc., Trans. 19. pp. 817–838, March, 1924.)—Discussion on various papers referred to in Abstracts 2369, 2623, 2631, 2632, 2635, 2636, 2639, 2641 and 2644 (1924).

2876. *The Prevention of Case Hardening by Copper Plating.* **J. C. McCullough** and **O. M. Reiff.** (Indust. and Engin. Chem. 16. pp. 611–613, June, 1924.)—Selective case-hardening has recently come into prominence through the development of the automobile industry. The various methods of restricting case-hardening to certain parts of the pieces depend upon exposing to carbon monoxide gas only those surfaces that are to be hardened, and so covering the other surfaces that the gas cannot reach them. Three methods of covering the surfaces to be protected are in use :—

1. Covering with iron. This consists of so arranging the pieces that the surfaces to be protected are in contact, one protecting another, or by covering certain parts with thin plates or sleeves of iron that may be discarded later.

2. Covering with a silicate cement or other non-metallic coating. Wood and McMullan have reported on the effectiveness of such coatings, and have found that sodium silicate mixed with finely ground asbestos or aluminium oxide is the best covering of this class.

3. Covering with a coating of copper or other metal deposited electrolytically or by the Schoop spray. Copper plated from a cyanide bath has been found satisfactory under many conditions and is quite commonly used, but cannot always be relied upon, as it fails to prevent carburisation in some pieces, while it protects others that have been treated in exactly the same way. This method has been under investigation by McCullough and Pray, who have showed that copper may be depended upon to prevent carburisation if the copper-plating is free from holes, but that the condition of the plating is affected by several factors, and that it is not always easy to secure good deposits. It was shown also that slag and oxide impurities in the surface of the iron cause openings in the copper-plating through which the carburising gases may enter, and also that copper deposited at high current densities is likely to be too porous to afford good protection unless very thick deposits are used.

The authors' continuation of the study has supported these preliminary claims and has also shown that volatilisation of the copper may leave bare spots, especially where non-conducting impurities in the surface of the steel have been but thinly covered with copper. Their further investigation of the protective action of copper in case-hardening has led them to the following conclusions :—

1. Penetration occurs only through holes in the copper plate.

2. Breaks in the copper are due to (*a*) non-conducting impurities that fail to plate over properly ; (*b*) high current density, giving a porous deposit, thus requiring a much thicker plating for complete protection ; and (*c*) vaporisation of copper, leaving bare spots, especially over non-conducting impurities, which are not so heavily covered as the pure iron.

3. The potassium ferricyanide test is a reliable indicator of the condition of the copper-plating on any sample, and will show which pieces to return for heavier plating, or even for cleaning and replating.

J. B. C. K.

NAME INDEX.

Allen, H. S., 2768.
Allison, S. K., 2745.
Altieri, V. J., 2855.
Anderson, W. A., 2721.
v. Angerer, E., 2770.
Arkadiew, W., 2760.
Arnulf, A., 2798.
Athanasiu, G., 2765.
Bäcklin, E., 2780.
Balandin, A., 2746.
Baly, E. C. C., 2716.
Barnes, J., 2739.
Bearden, J. A., 2786.
Beck, C., 2723.
le Bel, J. H., 2808.
Bennewitz, K., 2805.
Berger, E., 2806.
Bjerrum, N., 2853.
Blackwood, O., 2722.
Bodin, 2755.
Böhlin, K., 2655.
Borelius, G., 2797.
Born, M., 2660, 2677, 2863.
Bose, 2812.
Bose, S. N., 2752.
Boutaric, A., 2869.
Bowen, I. S., 2772.
Brennen, J. H., 2843.
de Broglie, M., 2758.
Bruhat, G., 2713.
Bucherer, A. H., 2674.
Buckingham, E., 2668.
Büchi, P. F., 2862.
Butler, J. A. V., 2857.
Byk, A., 2803.
Cabannes, J., 2681, 2740.
Calthrop, J. E., 2661.
Campbell, L., 2703.
Chapman, Muriel C. C., 2741.
Chapman, S., 2683, 2810.
Chenault, R. L., 2762.
Chree, C., 2682, 2688.
Cilliers, A. C., 2663.
Cioffi, P. P., 2839.
Cisotti, U., 2658.
Clark, L. H., 2841.
Coehn, A., 2820.
Compton, A. H., 2785.
Compton, K. T., 2766, 2767, 2828.
Cortie, A. L., 2695.
Czerny, M., 2753.
Daniels, F., 2801.
Danjon, A., 2728.
Dauvillier, A., 2758, 2759.
Deslandres, H., 2761.
Desrivières, Escher-, J., 2794.
Dévé, C., 2738.
Doodson, A. T., 2692.
Duane, W., 2745.
Duhme, E., 2820.
Dunoyer, L., 2727, 2837.
Eckart, C. H., 2828.
Einstein, A., 2724.
Errera, J., 2818.
Escher-Desrivières, J., 2794.
Falkenhagen, H., 2749.
Försterling, K., 2783.
Foote, P. D., 2762.
Fowler, R. H., 2700.
Frenkel, J., 2844.
Frenzel, C., 2866.
Freundlich, E., 2775.
Froelich, Clara L., 2711.
Gans, R., 2710, 2712.
Gehrcke, E., 2751.
Gerlach, W., 2662, 2663, 2748.
Gieseler, H., 2846.
Goens, E., 2659.
Goldsmith, L. D., 2814.
Gonell, H. W., 2788.
v. d. Grinten, K., 2842.
Grotrian, W., 2846.
Grüneisen, E., 2659.
Günther-Schulze, A., 2864.
Guinchant, J., 2679.
Gunnayya, D., 2845.
Gyemant, A., 2744.
Hachey, H. B., 2686.
Haertel, Pflieger-, H., 2657.
Hahn, O., 2763.
Haines, W. C., 2684.
Hainsworth, W., 2810.
Hantzsch, A., 2859.
Hazard, D. L., 2696.
Heisenberg, W., 2789.
Henri, V., 2774.
Hettner, G., 2725.
Heyl, P. R., 2678.
Hicks, W. M., 2750.
Hill, R., 2729.
v. Hirsch, R., 2747.
Hjort, E. V., 2722.
Hocheim, E., 2775.
Hodler, A., 2807.
Højendahl, K., 2835.
Hollenberg, M. S., 2720.
Iliin, B., 2848.
Iredale, T., 2847.
v. Issendorff, J., 2831.
Jackson, W. E. W., 2694.
Jauncey, G. E. M., 2791.
Jette, E. R., 2790.
Jevons, W., 2764.
Job, P., 2854.
Johansson, C. H., 2797.
Johnson, E. B., 2851.
Johnson, R. C., 2769.
Jones, O., 2733.
Joos, G., 2669, 2770.
Jordan, H., 2840.
Julius, W. H., 2757.
Käppler, G., 2735.
Katz, J. R., 2781.
Keyes, F. G., 2809.
Kirchner, F., 2830.
Kremann, R., 2867.
Krueger, E., 2718.
Kulenkampff, H., 2669.
Kussmann, A., 2804.
Laboccetta, L., 2655.
Laing, Mary E., 2871.
Lanczos, K., 2675.
Lange, F., 2802.
Lartigue, A., 2813.
de László, H., 2774.
Lau, E., 2751.
v. Laue, M., 2664.
Lecomte, J., 2756.
Leistner, K., 2743.
Lemaître, G., 2671.
Lémeray, 2673.
Lenouvel, L., 2737.
Lepape, A., 2740, 2795.
Lewschin, W. L., 2734.
Lindau, P., 2773.
Lindholm, F., 2685.
Loeb, L. B., 2832.
Lorenz, R., 2868.
Lowy, A., 2722.
Maass, O., 2858.
McAdie, A., 2690.
McBain, J. W., 2782, 2870.
McCullough, J. C., 2876.
McLennan, J. C., 2771.
Magnus, A., 2807.
de Mallemann, R., 2717.
Margary, I. D., 2691.
Mears, A. H., 2730.
Meitner, L., 2763, 2796.
Michkovitch, V., 2704.
Millikan, R. A., 2665, 2666, 2667, 2772.
Milne, E. A., 2700.
Möbius, W., 2743.
Mohammad, W., 2792.
Mohler, F. L., 2762.
Morton, R. A., 2716.
Morton, W. B., 2653.
Moureu, C., 2795.
Moureu, H., 2795.
Narayan, A. L., 2845.
Newman, F. H., 2777.
du Növy, P. L., 2852.
Nordheim, L., 2811.
Noumerov, B. V., 2699.
Noyes, W. A., jr., 2825.
Oelkers, K., 2826.
Ôkubo, J., 2827.
Paget, R. A. S., 2817.
Palmaer, W., 2856.
Palmer, W. G., 2850.
Paul, T., 2874.
Pauthenier, M., 2713.
Payne, Cecilia H., 2707.
Perreau (Miss), G., 2869.
Pflieger-Haertel, H., 2657.
Phragmén, G., 2790.
Pickering, W. H., 2705.
Proudman, J., 2692.
Ramspeck, A., 2715.
Rayleigh (Lord), 2860.
Reboul, G., 2755.
v. Rehenburg, R. G., 2867.
Reiff, O. M., 2876.
Relf, E. F., 2823.
Rhodes, F. H., 2851.
Riéty, L., 2822.

[*Continued at foot of page 4 of Cover.*

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NAME INDEX—*continued.*

Riley, H. L., 2861.
Röhrig, H., 2815.
Röstad, A., 2689.
Rohn, W., 2838.
v. Rohr, M., 2742.
Ross, P. A., 2784.
Ruark, A. E., 2762.
Russell, H. N., 2697, 2767.
Russell, R. P., 2855.
Saha, M. N., 2708.
Schottky, W., 2831.
Schreiner, E., 2873.
Schulze, Günther-, A., 2864.
Scares, F. H., 2701, 2702.
Seeliger, R., 2827.
Sexl, T., 2819.
Shapley, H., 2698.
Shikata, M., 2865.
Shook, G. A., 2731.
Shoulejkin, W., 2714.
Shrum, G. M., 2771.
Silberstein, L., 2672.
Simeon, F., 2732.
Simon, A. W., 2821.
Simon, F., 2834.
Smekal, A., 2793.
Socolow, A. P., 2693.
Southwell, R. V., 2652.
Stern, O., 2662.
Stolt, H., 2829.
Strohhäcker, I., 2824.
Strotker, D. H., 2730.
Szivesy, G., 2719.
Temple, G., 2670.
Thoraeus, R., 2779.
Toulon, P., 2837.
Turner, L. A., 2766.
Uno, D., 2816.
Vegard, L., 2776, 2778.
van Vleck, J. H., 2849.
Vogt, H., 2709.
Volmer, T., 2833.
de Vries, O., 2651.
Walker, E. E., 2654.
Walter, B., 2787.
Watters, B. D. H., 2754.
Weigert, F., 2735.
Wessel, W., 2872.
Westgren, A. F., 2790.
Weyl, H., 2676.
Whippie, F. J. W., 2680.
Whitman, W. G., 2855.
Williams, J. W., 2801.
Wolfers, F., 2736.
Wood, R. W., 2726.
Würschmidt, J., 2800.
Yovanovitch, D., 2799.
Zachmann, E., 2836.

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